ZOOLOGY

TEXTBOOK FOR THE 6th AND 7th FORMS

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TEXTBOOK
FOR THE 6TH AND 7TH FORMS

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INTRODUCTION

§ 1. ZOOLOGY — A STUDY OF ANIMAL LIFE

The Animal Kingdom. Its Variety. Animals are found all over the world: from the frost-bound Arctic countries to the hot tropical areas, on mountain peaks and in the depths of the sea. Quite a number live in the same geographical zone as you do. (Think of the different animals you have seen.)

Everyone knows the *domestic animals* and has heard about *bears* and *wolves*, and has seen *birds*, *lizards* and *frogs*; everyone has eaten *fish* and some of you have even gone fishing. *Insects*, *worms* and *snails* are also animals. Some animals, like bacteria and one-celled algae, can be seen only under a microscope.

The animal kingdom is more varied than that of the plants. There are some 500,000 different species of plants and 1,500,000 different species of animals, i. e., three times as many. (Look through the book for pictures of different animals.)

Animals live in very different kinds of places, or, as we say, have different "*natural homes*" (*habitats*). Fish live in water; *polar bears* prefer the shores of the Arctic Ocean and its ice-floes (see inside front cover), while *brown bears* like forests (ibid.). Susliks, which are never found in forests, are very plentiful on the steppes. (See picture on back cover.) *Earthworms* live in the soil and burrow their way to the surface only after rain.

The animals on the sea bottom are even more varied. (See inside back cover.)

Some animals are parasites that live in the bodies of other animals, for instance, the *intestinal worms*.

Animals eat a great variety of food. (Remember the varying diets of a rabbit, a wolf and a bee.)

Excavations have revealed solid remains of animals which earlier inhabited our planet but are now extinct. (Remember fossil ferns.)

On many occasions the finds consisted of *mammoth* bones and teeth. On a fossil mammoth excavated in the frigid zone in Siberia some muscles and fur had even been preserved. Mammoths were like elephants but were covered with thick fur because they lived in areas where the climate was very cold (Fig. 1).

The fossils prove that the animal kingdom has not remained unchanged (an incorrect religious theory) but has been in a process of steady and continuous development.

Animals and Plants. Animals and plants are similar in many ways: they need food for their nutrition; they breathe; they grow and reproduce. Their bodies consist of cells.

But at the same time, they are different primarily with regard to their food requirements. Green plants grow by absorbing carbon dioxide from the air, and water and mineral salts from the soil. They use these *inorganic* materials to make up *organic* substances (carbohydrates, fats and proteins) in the presence of sunlight. Animals cannot live on such a diet. They need plants or other animals — they get their food from ready-made *organic* matter.

Other distinctive features of animals are their organs of movement, their nervous system and sense organs, all of which plants lack.

The above-mentioned distinctive features are not always present. There are plants which feed on organic matter (for instance, the fungi) and some which are able to swim about (for example, a number of algae). On the other hand, some animals are immobile.

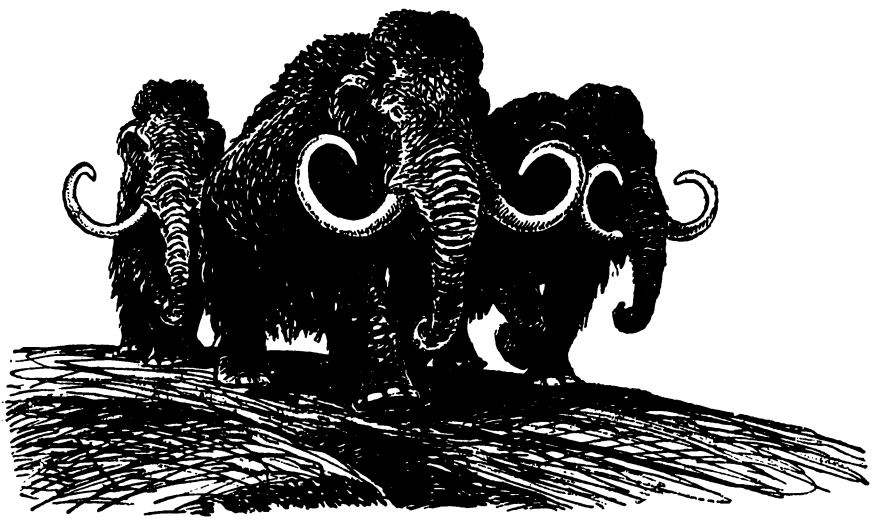

Fig. 1. Mammoths.

The two groups of living organisms, animals and plants, form the organic world. They are closely connected. Plants take in inorganic materials and build up organic ones which animals use as food. Animals, for their part, discharge carbon dioxide which is absorbed by plants as part of their nutrition.

Importance of Zoology. Animals play a big part in man's life. Ages ago primitive people hunted them for meat and hides to make clothing and footwear. Some of the animals were gradually tamed and domesticated. At present they provide us with meat and dairy produce as well as raw materials for making our clothes and footwear.

Many of the wild animals are also of use to man. The seas and rivers are full of fish which we eat; in the woods there are fur-bearing animals whose pelts are very valuable; useful birds live everywhere, constantly destroying insects harmful to orchards and crops.

Some of the animals, however, are quite harmful. Many insects cause damage to plantations, orchards and woods. (Which of them do you know?) Wolves are known to attack domestic animals. Mice and rats are a grave threat to foodstores. Flies and lice spread disease. Persistent struggle must be carried on against them.

To protect useful animals, to take proper care of domestic animals, and to combat harmful animals, it is necessary to know all about their habits and constitutions. This is exactly what zoology as a science is interested in. Zoology studies animal life.

Chapter One

PROTOZOA (FIRST ANIMALS)

§ 2. PARAMECIUM (SLIPPER ANIMALCULE)

Discovery. Some 300 years ago an event took place that was very important in the history of natural science. A Dutchman, Anton van Leeuwenhoek, a skilful polisher of magnifying lenses, while examining, under a microscope he himself had built, a drop of rainwater, which had been kept in a barrel for some time, was astonished to find that the turbid liquid he had considered lifeless was very far from being so. It was such an unexpected discovery that he could not help calling out in surprise. Very soon he realised that what he had seen were tiny living animals no one had even heard of before. Leeuwenhoek called them "the smallest animals". Later, having studied their structure, scientists named them *Protozoa.*

By discovering the tiny living things that could not be detected by the naked eye, Leeuwenhoek did a great service to science and mankind, and he also has the credit of being the first to use the microscope to study Nature. The gradual improvement of the microscope and its systematic use in research led to a great many other discoveries, for instance, that of many minute disease-causing agents. This, in turn, assisted in the development of effective methods of treating infectious diseases and helped to free people from many religious prejudices.

Habitat (Natural Home). A *Paramecium* (Fig. 2) is easier to detect in a drop of fresh water viewed under a microscope than other Protozoa. It is shaped like a slipper, whence it derives its name (Slipper Animalcule).

Paramecia are commonly found in wet or moist places and fresh or stagnant water that contains decayed vegetable matter. This is their natural home.

In laboratories a culture of Paramecia can be obtained by placing some finely chopped hay in water and leaving the infusion for a time in a warm place.

Anton van Leeuwenhoek.

Structure. To observe a Paramecium place a drop of hay infusion on a glass slide under a microscope (Fig. 2). In order to prevent the Paramecium from moving out of view, place a cover glass over the drop of water. The excess water that is squeezed out should be carefully removed with blotting paper. When the cover glass is lowered the Paramecia are secured in position. Only a small degree of magnification is needed to reveal the Paramecium which has a soft, transparent body, about 0.25 mm. long. This is made up of *protoplasm* (remember your botany lessons) and surrounded by a somewhat tough outer *layer* which helps the Paramecium to maintain a constant shape. Inside is a large oval *macronucleus* seen only upon the introduction of certain stains. Next to it is the so-called *micronucleus*.

The blob of protoplasm with a nucleus inside is called a *cell*. The Paramecium is a one-celled living organism with two nuclei. Like all other animal cells it has no chlorophyll and is incapable of absorbing carbon dioxide from the air.

Locomotion. In its search for food the Paramecium swims rapidly about, propelled by the action of little hair-like *cilia*, which cover its body and act like tiny oars. The beating of the cilia drives the animal forward, while at the same time its body rotates upon its own longitudinal axis.

Questions: 1. Why was A. Van Leeuwenhoek's research so important? 2. Where are Paramecia commonly found? 3. In what way does a Paramecium resemble a plant cell, and what is the difference between them? 4. How does a Paramecium move from one place to another?

Nutrition: The Paramecium feeds on organic matter called bacteria (mostly hay bacilli).

By beating its cilia, the Paramecium sets up a current which draws the bacteria into a depression called the *vestibule*. From there it is taken into the *mouth* which leads into the *gullet*. The food is accumulated in the gullet and surrounded by digestive juices. A *food vacuole* is formed, which breaks away from the gullet and travels slowly through the protoplasm. The food is gradually changed by the

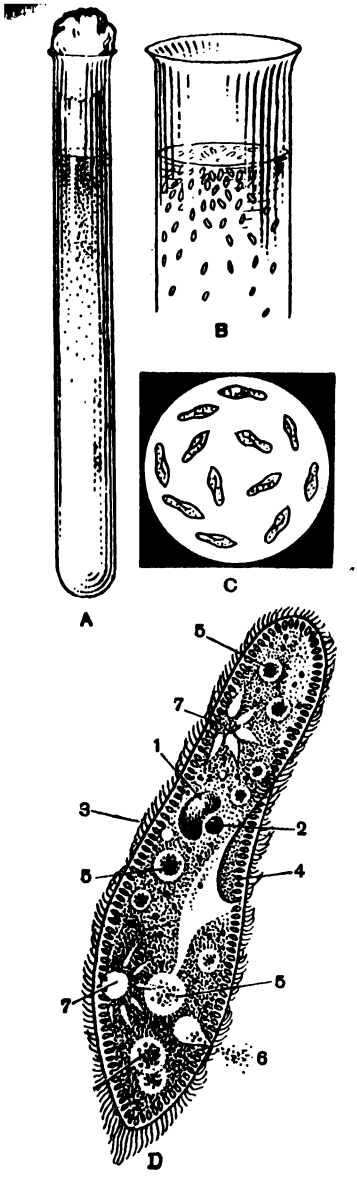

Fig. 2. Paramecia.

(*A*) Paramecia in a beaker of hay infusion. (*B*) The top section of the beaker (*A*) as seen through a magnifying glass. (*C*) Paramecia slightly magnified. (*D*) Greatly magnified Paramecium. *1*. Macronucleus. *2*. Micronucleus. *3*. Cilia. *4*. Vestibules. *5*. Food vacuoles. *6*. Excretion of undigested materials. *7*. Contractile vacuoles with the canals.

digestive juices, dissolved and absorbed by the protoplasm. The Paramecium assimilates the digested food while the undigested remains are thrown out of the food vacuole through a hole at the broader end of the animal's body.

Respiration. Paramecia die when placed in cool, boiled, airless water. This means they cannot exist without air, and are in constant need of oxygen. Like plants, they respire through their body surface. Water-dissolved oxygen is brought in through the surface layer; carbon dioxide is excreted into the water.

Excretion. As the Paramecium develops, part of it is constantly being destroyed and the waste matter harmful to the organism, is passed out together with surplus water through two contractile vacuoles.

The *contractile vacuoles* look like two silvery bubbles which fill up and contract alternately. With their radiating canals they are like tiny stars. Water which accumulates in the protoplasm, and the dissolved waste materials (excreta) pass into the vacuole canals. This is when they most resemble little stars. When the canals are full they collapse discharging the waste solutions into the vacuole. The vacuoles alternately fill up and collapse, and the waste materials are expelled from the animal's body.

Irritability. If we place a crystal of table salt at the edge of a drop of hay infusion the Paramecia will immediately retreat to that

part of the drop where the salt content is less. If we put another drop of salt-free hay infusion near the drop, and connect the two, the Paramecia will migrate into the saltfree drop (Fig. 3).

Now, if we introduce bacteria into the drop of water the Paramecia will quickly swim to them and draw them in.

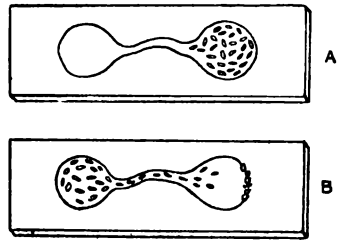

Fig. 3. Irritability.
(*A*) Paramecia in the right-hand drop of hay infusion. (*B*) Salt crystals are introduced and Paramecia migrate to the left-hand drop.

These experiments prove that Paramecia are irritated by the presence of salt and bacteria. They try to escape from the former and move nearer to the latter. The reaction of animals to outside influences is called *irritability.*

Reproduction. In the warmer seasons when there is a plentiful food supply in the pond, the Paramecia grow fast and then divide. Each of the nuclei splits into two, and a groove appears across the middle of the body (Fig. 4). It deepens and the body separates into two approximately equal parts. The "daughter" cells then grow to their maximum size and again divide about a day later.

Encystment. If the water in the pond where the Paramecia live dries out suddenly, they die. They cannot exist without water. Water is essential for all their vital processes — nutrition, excretion, etc.

If the drying out process is slow the body of the Paramecium takes a round shape and forms a hard resistant wall, a *cyst.* This condition is known as *encystment.* The Paramecium does not take in food and remains immobile. Life seems suspended, but the animal does not die. If a gust of wind carries the cysts into another reservoir they burst and the Paramecia become lively and active again. The cysts are capable of withstanding drought, low temperatures, and other unfavourable conditions.

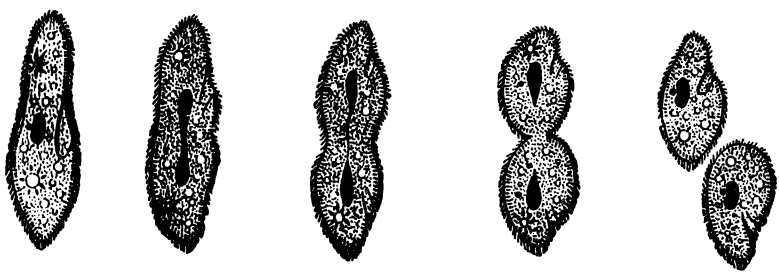

Fig. 4. Reproduction.
(See from left to right.)

Their Importance. By eating up bacteria Paramecia clean up reservoirs. In their turn, they serve as food for fish, crustaceans, molluscs, etc. Reproducing fast, the Paramecia in their millions play an important part in the life of Nature.

Questions: 1. What do Paramecia feed on? 2. How do they respire? 3. How do they excrete? 4. How do they reproduce? 5. How do they withstand unfavourable conditions? 6. What is their role in Nature?

§ 3. COMMON AMOEBA

Habitat. Like the Paramecium, the *Common Amoeba* (Fig. 5) lives in moist and wet places, mostly in shallow stagnant fresh-water ponds easily warmed by the sun. It creeps slowly on the bottom among the decaying debris of plants.

To catch some Amoebae lower a glass vessel into a reservoir and fill it with water from the bottom. There will probably be Amoebae among the organic debris you bring up. In the laboratory place a drop of the water on a glass slide and examine it through a microscope. Only a small degree of magnification is sufficient.

Structure. The Amoeba is a tiny blob of mucus, irregular in form, with an oval corpuscle inside. The mucus is *protoplasm* and the corpuscle is a *nucleus*. The Amoeba is a single-celled animal, like the Paramecium. It also has no chlorophyll.

Locomotion. When you examine an Amoeba under a microscope, you will notice that as it moves parts of its body flow out in the direction of the movement forming *pseudopodia* (false feet) (Fig. 6). As the pseudopodia are pushed out they become longer and broader, the protoplasm flowing towards and into them. The Amoeba moves about as if flowing from one place to another. In time it can even get out of microscopic view.

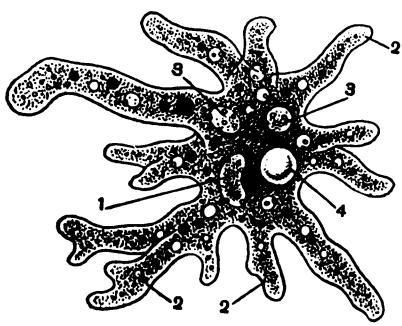

Fig. 5. Common Amoeba.
1. Nucleus. *2*. Pseudopodia (false feet). *3*. Food vacuoles. *4*. Contractile vacuole.

As it moves, the shape of the Amoeba's body constantly changes. In Greek, the word "*amoibe*" means "*change*".

Nutrition. The Amoeba takes in organic matter found in microscopic algae. It does not have to move fast to obtain its food. Its protoplasm slowly surrounds an immobile particle and gradually draws it inside (Fig. 6). There, the particle is surrounded by a drop

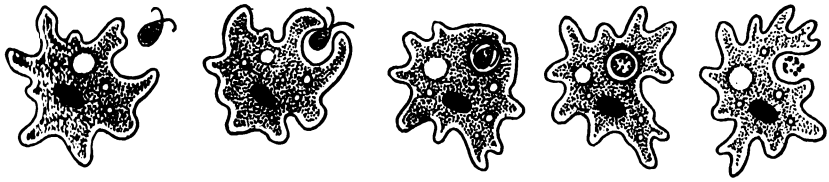

Fig. 6. Amoeba in movement and drawing in food.
(See from left to right.)

of digestive juice. A *food vacuole* is formed. The particle is digested — in other words, it is dissolved. Dissolved food is used to build up the body of the Amoeba. As the undigested food remains are pushed out, the food vacuole bursts.

Food can be taken in and the unused remains excreted from any part of the body.

Respiration. The Amoeba respires in the same way as the Paramecium: by absorbing oxygen and excreting carbon dioxide. Respiration is effected by the entire body surface. Since the animal is very small, oxygen, dissolved in water, easily passes into all sections of the protoplasm. The process of carbon dioxide excretion is equally simple.

Excretion. In the protoplasm a light bubble containing a drop of transparent fluid can easily be seen. This is the contractile vacuole. From time to time, the vacuole bursts and the fluid is excreted. Then it appears again, is gradually filled with transparent fluid, and bursts.

That is how the Amoeba excretes, i. e., gets rid of water and the waste materials dissolved in it.

Irritation and Excitability. If you shine a ray of light on one section of a drop of water containing Amoebae, the animals will move to the darker side. This shows that they react to light and respond with physical movement.

If you introduce a crystal of table salt, the movements of the Amoebae will become slower, the pseudopodia will be drawn in, and the animals will assume a rounded shape. This means, the Amoebae react to salt and respond by changing their shapes.

Experiments have shown that among agents affecting the Amoebae, apart from light and salt solutions, are food, warmth, and oxygen. Under

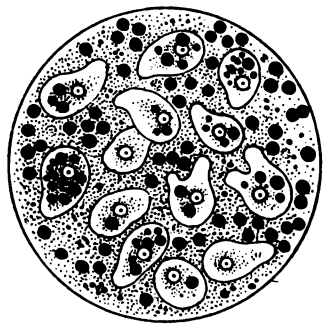

Fig. 7. Dysenteriae under a microscope.
(Excreta from a sick person. The dark dots are red blood corpuscles.)

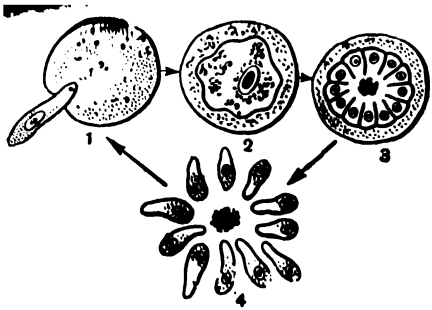

Fig. 8. The growth of a malaria parasite.
1. Attack on a red blood corpuscle. *2.* Growth. *3.* Splitting. *4.* Formation of new parasites and the bursting of the blood corpuscle.

the influence of these and other stimuli sensitivity is produced in the protoplasm of the Amoeba (and other animals as well). The animal reacts to the stimulation with physical movement.

This physical response makes it possible for the animal to adapt itself to changes in its surroundings. Bright light means death, so the Amoebae move into dark places. By drawing in their pseudopodia they diminish the area of body surface exposed to the harmful effects of the salt solution.

Reproduction. The Amoeba multiplies by simply dividing into two. It takes an oblong shape; its nucleus pulls into two portions, and the portions part. A "waist" appears in the protoplasm, which becomes narrower. Finally, the body of the "mother" Amoeba separates into two smaller "daughters".

Encystment. If the reservoir dries out the body of the Amoeba takes on a round shape and is covered with a tough wall. This wall is called a *cyst*. In this condition the Amoeba easily withstands not only lack of moisture but also frost. As soon as the cyst is again surrounded by water, the wall bursts and the Amoeba comes out.

Dysenteriae. The Common Amoeba is harmless to man. Even if it gets into his intestine in dirty water, it is easily digested. The *Dysenteriae* are different (Fig. 7). They attack the intestinal walls causing bleeding ulcers. *Amoebic dysentery* may cause death to man. Infection may result from drinking unboiled water from sources contaminated by the excreta of people suffering from amoebic dysentery.

Questions: 1. What are the main parts of a plant and of an animal cell? 2. What is the difference between an animal cell and a plant cell (compare the Amoeba and a single-celled alga)? 3. How does the Amoeba breathe and feed? 4. How does it move? 5. What is the role of the contractile vacuole? 6. How does the Amoeba reproduce? 7. Why is it dangerous to drink unboiled water? 8. In what way is the structure of the Amoeba simpler than that of the Paramecium?

§ 4. MALARIA PARASITE

Pathogenic Agent. Using the microscope scientists have been able to study the structure of human blood, which was found to consist of transparent fluid and tiny red blood corpuscles swimming

therein. It is these corpuscles that make blood red. In man's lungs they combine with oxygen which they carry to all the living cells of the body. In the last century, the red blood corpuscles of patients suffering from malaria were found to contain many Amoeba-like single-celled parasites.

Having penetrated a red blood corpuscle, the parasite grows at its expense. The full-grown parasite fills the entire corpuscle and then divides into several parts, not in two as the Amoeba does (Fig. 8). Between 8 and 12 new parasites are formed, which burst the corpuscle and penetrate the blood stream along with the toxic excreta of the mother-parasite. The action of the toxic excreta on the human body causes a severe attack of fever. As for the young parasites, they get into healthy blood corpuscles, consume them, and burst them in a couple of days.

The attacks of fever coincide with the entry of malaria parasites into the blood stream and recur regularly, in some cases every twenty-four hours, in others—at intervals of two to three days. The number of parasites in the blood keeps increasing and a tremendous number of red blood corpuscles are destroyed. If the sick person does not receive timely medical attention, he may die.

Transmitting Agent. Man gets malaria parasites from the malaria-carrying Mosquito (see § 25). The Mosquito bites, and the parasites are injected into the man's organism with the saliva from the insect. After a certain period attacks of malaria begin.

The Mosquito gets the parasites when it bites people suffering from malaria. Inside the Mosquito, the parasites multiply rapidly. In a few days, they fill the salivary glands of the Mosquito which becomes a malaria-carrier.

Mosquito eggs are laid in shallow stagnant water. Therefore malaria is widespread in marshy places, especially where the climate is warm. Previously it was called "marsh fever".

Anti-malaria Service in the USSR. In tsarist Russia thousands of people died of malaria. The number of cases was particularly great in some southern areas where entire villages and townships were wiped out.

During Soviet times, a large-scale anti-malaria drive has been carried out. The breeding-places of the Mosquito were drained. Where drainage was impossible or difficult, surface waters were sprayed with oil or dusted with toxicants. In

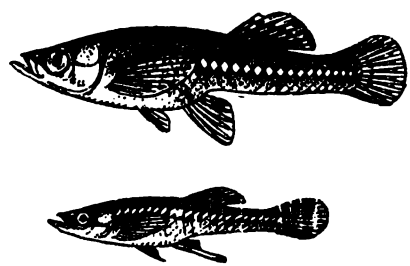

Fig. 9. Mosquito-fish.
Top—a female; *bottom*—a male.

some cases the reservoirs were stocked with fish—Mosquito-fish (Fig. 9) in the south, Carassius and Carp (Fig. 93) in the northern regions. Fish eat the Mosquito larvae.

Much importance is attached to fighting malaria-carrying Mosquitoes. They shelter during the winter on cattle-farms, in cellars and other unheated premises, in hollow trees and rock caves. All these places are dusted with toxicants—DDT and hexachloran.

Great attention is also paid to treating infected persons. Previously, the basic medicine used was quinine: penetrating a sick person's blood it kills the malaria parasites. However, there are no cinchona-trees (fever-trees) on the territory of the Soviet Union. Therefore, scientists directed their efforts to finding other anti-malaria drugs. Out of cheap home-made raw material they evolved quinacrine, whose properties are not inferior to those of natural quinine. Mass production of other anti-malaria medicines is underway.

As you have seen, the fight against malaria has been conducted in two directions: 1. Treatment of infected persons, and 2. The annihilation of malaria-carrying Mosquitoes. All this has become possible after thorough study of the life-cycle of the malaria parasite and the means of infection.

In the Soviet Union, malaria is no longer widespread. However, in many capitalist and colonial countries it takes a toll of millions of lives.

Conclusion. The specific feature of the Protozoa, that distinguishes them from all other animals, is that they are all single-celled. The rest of the animal kingdom are multicellular.

The Protozoa are microscopically small. They are either barely visible to the naked eye, or not visible at all. They can only live in fluids: water, blood, etc.

Their structure is so simple that it is quite possible that they belong to the most ancient group of animals to have lived on the Earth.

Questions: 1. Why does a malaria parasite cause fever? 2. How does a person become infected with malaria? 3. What is done to combat malaria in the USSR? 4. What are the distinctive features of the Protozoa?

Chapter Two

COELENTERATA

§ 5. HYDRA — A CARNIVOROUS, FRESH-WATER ANIMAL

Habitat. The Hydra lives in not too stagnant fresh-water ponds, lakes and quiet back-waters (Fig. 10). Increasing contamination by decaying debris leads to its death.

Hydras commonly cling to plants which discharge oxygen into water. On a bright summer day they can be seen as small, greyish tentacled cylinders, up to 2 cm. long, hanging from floating leaves.

Structure. The Hydra attaches itself to water plants by its *base.* At the opposite end is the *mouth*, on a small cone. The mouth is surrounded with thread-like *tentacles* (six to twelve).

The body is shaped like a sac (Fig. 11). The mouth leads into a *digestive cavity*, the *enteron.* The cavity extends throughout the body and into the tentacles. In the cavity food is digested. The Hydra has no anus. Therefore, the undigested food is pushed out through the mouth.

The body wall is composed of two layers of cells—*ectoderm*, or the outer (protective) layer, and *endoderm*, or the inner (digestive) layer. In between, there is a thin cell-less *supporting layer*, which performs the functions of a skeleton.

Locomotion. If you gently shake a vessel containing Hydras, their bodies will shrink fast and the tentacles will be drawn in somewhat. If you prick them with a dissecting needle you will

Fig. 10. This is what the Hydra looks like.

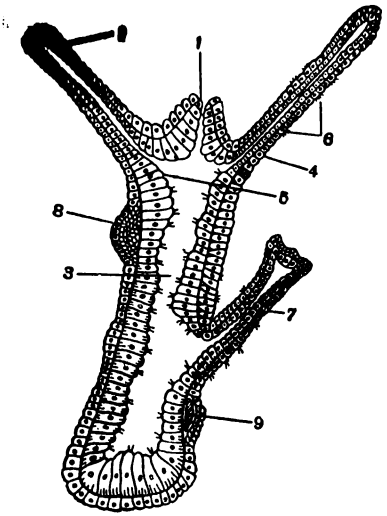

Fig. 11. Hydra. Diagram of a longitudinal section.
1. Mouth. *2*. Tentacle. *3*. Enteron. *4*. Ectoderm. *5*. Endoderm. *6*. Stinging cells. *7*. Bud development. *8*. Spermatocyte. *9*. Ovary.

observe the same effect. The movements of the Hydra prove that it belongs to the animal kingdom.

When watching Hydras in an aquarium you will notice that they have different methods of locomotion (Fig. 12). One may slowly bend its body, cling to a plant by its mouth, detach the base, and transfer it to another place. It is like executing a somersault. Another may draw the base to its mouth after bending its body into a loop. Sometimes it clasps a plant with its tentacles and shins up like a real gymnast.

Capture of food. Often one sees how a water flea (Fig. 70), swimming past a Hydra comes in contact with its tentacles and stops as if paralysed. The tentacles stretch out and seize the flea which is pushed into the Hydra's mouth. The mouth of the Hydra can stretch considerably so that the animal can swallow not only water fleas but also young fish, considerably larger than the Hydra itself.

The ability to move freely and consume organic food are features specific to animals. Consequently, the Hydra is an animal, and a carnivorous one.

Symmetry. The Hydra clings to a plant with its base and hangs mouth down in the water. In this position, it can expect prey to come from all sides. That is why the tentacles grow fanwise around the mouth. No matter from which direction the prey comes, it is sure to be caught.

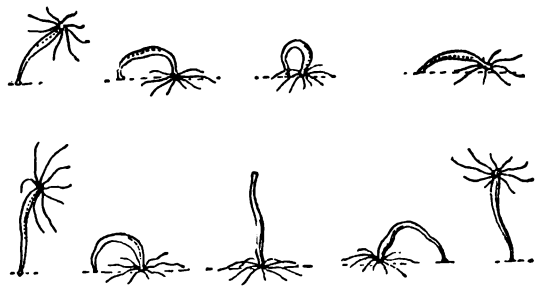

Fig. 12. Methods of movement.
Top—looping (different stages); *bottom*: somersaulting. (See from left to right.)

The body of the Hydra can be dissected into several symmetrical, i. e., completely identical, parts (Fig. 13). The dissecting lines will cross at the centre of the mouth, fanning out like rays. The Hydra has a *radial symmetry.*

Questions: 1. What is the body of the Hydra like? 2. Why do we say that the Hydra belongs to the animal kingdom? 3. How does the Hydra move? 4. How does it catch its food?

§ 6. HYDRA — A MULTICELLULAR ANIMAL

Musculo-epithelial Cells. The outer layer of the Hydra's body mainly consists of *musculo-epithelial cells* (Fig. 14). The end of the cell, which is directed to the outside of the animal, forms part of the *body wall.* The opposite end, adjoining the supporting layer, becomes elongated and forms two fibres that lie along the body and contract as a result of irritation. If the process simultaneously affects the fibres of all the musculo-epithelial cells, the body of the Hydra shrinks.

Nerve Cells. The *nerve cells* are found in the ectoderm and are star-shaped, with a big *nucleus* inside and long thin protoplasmic *branches.* Since the branches are connected with each other, the cells form a primitive network which can be regarded as a *nervous system* (Fig. 15).

One of the characteristic features of the nerve cells is their quick response to stimuli and their ability instantaneously to convey impulses to other cells. If a passing water flea touches one of the Hydra's tentacles, the nerve cells of the tentacles react. The impulse spreads throughout the nervous system and is passed to the musculo-epithelial cells. The fibres of the musculo-epithelial cells contract, the tentacles lean towards the prey and seize it.

The contractile fibres of the musculo-epithelial cells do not contract of their own volition but under the influence of impulses originating in the nerve cells.

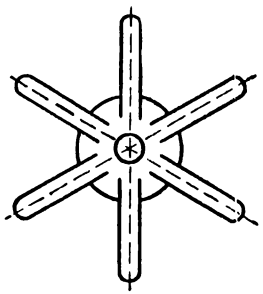

Fig. 13. Radial symmetry.
The Hydra as seen from the mouth (diagram). The mouth is in the centre. The tentacles spread fanwise. The dotted lines indicate the direction of possible dissection into identical parts.

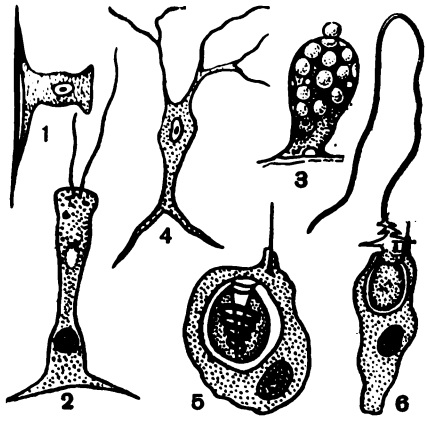

Fig. 14. Different types of cells in the body of the Hydra.
1. Musculo-epithelial cell. *2.* Endodermal cell. *3.* Gland cell. *4.* Nerve cell. *5.* Stinging cell. *6.* Stinging cell with its thread thrown out.

An organism's response to stimuli which occurs through the nervous system is called a *reflex*. The Hydra captures water fleas in response to the *food reflex*. The contraction of its body caused by a needle prick is called the *defensive reflex*.

Stinging Cells. The *stinging cells*, or *cnidoblasts*, are scattered in the ectoderm.

Each stinging cell is pear-shaped with an elastic thread coiled within (Fig. 14). On the narrow end of the cell is a very sensitive projection, the "cell trigger" (cnidocil). When a small living organism touches the cnidocil, the thread uncoils energetically, is pushed out of the cell and thrust into the prey. The toxic fluid ejected from the thread numbs the prey and the latter dies. The tentacles contract, seize the prey and take it to the mouth.

The stinging cells are more numerous in some parts of the body surface. In the tentacles, they are found in groups.

The stinging cells also have a defensive function. If you watch a Hydra in an aquarium you will notice how small fish sometimes swim hastily away from it. The Hydra has touched them with the poisonous threads of its stinging cells. However, to larger animals and human beings, the threads are harmless.

Digestive Cells. The endoderm of the Hydra has two different types of cells, *endodermal* and *gland cells* (Fig. 14). On the ends lining the body cavity (enteron) the endodermal cells develop *flagella*. The gland cells do not.

When food touches the walls of the enteron the gland cells secrete drops of digestive juice. The food is dissolved and drawn into the endodermal cells. The flagella of the endodermal cells quickly distribute the food over the entire cavity surface. As in the Amoeba, the cells can develop pseudopodia to embrace the food and draw it into the protoplasm. There, food

Fig. 15. The nervous system of the Hydra.

vacuoles are formed, digestion takes place, and the dissolved food is passed to the other cells of the animal's body, and absorbed.

Therefore, the Hydra can digest its food in two ways:

1. In the enteron, with the help of the juice secreted by the gland cells (*intracavitary digestion*).

2. In the endodermal cells (*intracellular digestion*).

The endodermal cells also play a definite role in locomotion. The ends lying close to the supporting layer are elongated and form two fibres, which are arranged along the body. When they contract the body of the Hydra becomes thinner and longer. This means, the fibres perform the functions of ringed muscles.

Tissues. The study of the Hydra shows that the different cells in its body are not identical in their importance and functions. Some play a defensive role, others are used to digest food, etc. Groups of cells, that are similar in structure and play similar roles in the life of the organism, are called *tissues.*

The cells which form the top layer of the Hydra are called the *cover tissue.* The star-like cells immediately underneath are a compound of the *nervous tissue.* The cells lining the enderon belong to the *digestive tissue.* The Hydra is also known to have primitive *muscular tissue.*

Respiration and Excretion. Since the body wall of the Hydra consists of only two layers of cells, oxygen gets into each cell easily. The discharge of carbon dioxide is also simple. The Hydra has no specialised organs of respiration. Respiration takes place from the body surface.

Neither has it separate organs of excretion, but discharges harmful fluids into the water through all its cells.

Budding. In summer, when food is plentiful, parts of the Hydra's body begin to bulge outwards. Both layers are involved in the formation of these buds (Fig. 11). The bulging continues until at the free end of the finger-like projection a mouth develops, around which grows a circle of tentacles. The buds grow into young Hydras.

For some time the enteron of the "daughter" is not separated from that of the "mother". Then the young Hydra detaches itself and starts an independent life. Reproduction by *budding* is asexual.

Regeneration. If you cut a Hydra in two, each half will build up the part it lacks. The same process takes place if you cut it into several pieces. New Hydras will grow from them. The restoration of lost parts is called *regeneration.* This is possible because the structure of the Hydra's body is very simple.

Sexual Reproduction. In autumn, when the water becomes cooler, food scarcer, and unfavourable conditions are approaching, the body of the Hydra begins to bulge in places. These projections, ho-

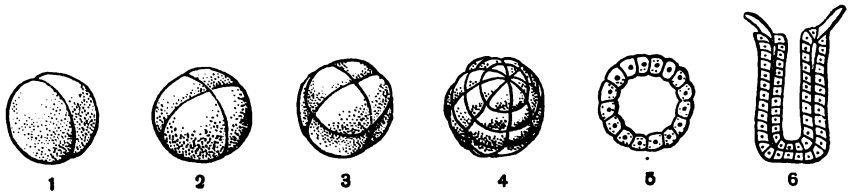

Fig. 16. Hydra development.
1—4. Initial stages of fission. *5—8.* Later stages (longitudinal section).

wever, are different from the buds. They grow from only one layer, the ectoderm. Some of them are large, with a big female germ cell, the *ovum*, inside; others give rise to a multitude of male germ cells, the so-called *sperm cells* or *spermatozoa* (Fig. 11).

Mature sperm cells are exceedingly mobile. They leave the body of the Hydra, swim in the water and penetrate the *ovaries* of other Hydras. Fertilization takes place and a new cell is formed out of two which fuse — the ovum (egg) and the spermatozoid (sperm).

In autumn the adult Hydras die, but their fertilized ova (eggs) are able to withstand the winter cold. Protected by a thick cyst they shelter at the bottom of the pond.

Division. Within the cyst, the fertilized ovum divides by fission into two, four, eight, sixteen, and more parts (Fig. 16). They do not burst the cyst, as those of the Amoeba do, but stay linked together. The process of fission stops in winter to be resumed the following spring when it leads to the development of a multicellular animal, a young Hydra.

The development of the Hydra out of one single cell is a vivid proof that multicellular animals are related to their one-celled counterparts.

Questions: 1. What cells and tissues form the body of the Hydra and what is their importance? 2. How does the Hydra take food? 3. What part does its nervous system play? 4. How does the Hydra breathe? 5. How does the Hydra excrete? 6. Why are green plants necessary in an aquarium where Hydras live? 7. How does the Hydra reproduce? 8. How can you prove that the Hydra develops out of one cell?

§ 7. MARINE COELENTERATES

Coral Polyps (Anthozoa). There are many forms related to the Hydra in the seas (see picture on the back inside cover). The most widespread are the *Coral Polyps.*

The so-called *Red Coral* grows on the sea floor and looks like a small shrub with many red branches and white flowers (Fig. 17).

The so-called flowers are really the tentacles of the tiny sea animals, called *polyps*, whose bodies form the shrub.

While the Hydras live as single individuals, the Coral Polyps form *colonies*.

The red "branches" are built of mineral salts, the same as in the hard skeletons of the animals. They have tubes inside, which link the enterons of the neighbour-polyps.

Fig. 17. Red Coral.

Food, which is also caught with the tentacles, is digested in a cavity that is identical with that of the Hydra. However, the digested material is distributed along the branch tubes to all the colony and is not used by only one polyp.

People collect Red Coral from the sea bottom, saw it up, polish it and make all kinds of ornaments (necklaces, earings, brooches).

The most remarkable feature of the Coral Polyps is their ability to extract from sea water and deposit in their bodies huge quantities of various mineral salts, which they use to make a hard, strong skeleton. Their most important building material is lime. Particularly massive are the skeletons of the Reef-building Corals, which sometimes resemble round loaves of bread with individual polyps sitting here and there in cosy nooks. When the animals die their skeletons are scattered over the bottom of the sea. Gradually they fossilise into limestone, a rock highly valued for building.

In the tropical seas, the Coral colonies grow fast and sometimes develop into great Coral reefs, dangerous to shipping. These reefs may stretch for hundreds of kilometres along the coast, forming solid underwater barriers which ships cannot pass. The Great Barrier Reef, off the Australian coast, is very well known. In some cases the polyps make ring-shaped islets—atolls—with a lagoon in the centre.

Medusa (Jellyfish). Unlike the Hydra and the Coral Polyp, the *Jellyfish* is not anchored and can move about freely in the sea (see picture on the back inside cover). It has a glassy, semi-transparent, gelatinous body, shaped like a bell or a saucer, turned upside down (Fig. 18). When the "saucer" contracts a jet of water is discharged from its undersurface, and the Jellyfish is jerked in the opposite direction. This method of locomotion could be called "jet propulsion".

Fig. 18. Medusa (Jellyfish).

The "saucer" is fringed with a row of *tentacles* equipped with groups of *stinging cells*, which can cause pain even to man. The stinging threads of some species of Jellyfish cause most unpleasant wounds which take a long time to heal.

The food of Jellyfish consists of small animals which are rendered helpless by the stinging cells and are captured by the tentacles. From the mouth the food goes to the central body cavity (the enteron) where it is digested.

The unused food is excreted from the mouth (remember the Hydra).

On a calm, bright, summer day, huge numbers of beautifully-coloured Coral Polyps can often be seen in the transparent water, with endless shadowy glasslike medusae floating above. At night, many of these sea animals are phosphorescent, and it seems that the light comes from the very depths—calm, serene and mysterious.

The flora and fauna of the land is wonderfully beautiful, but some of the marine varieties surpass even tropical flowers in their splendour, and not the flowers only but also the fluttering bright-coloured butterflies and birds as well.

Conclusion. The Hydras, the Corals and the Jellyfishes form one group of animals called the *Coelenterata* (Coelenterates). Unlike the Protozoa, they are multicellular. Their bodies have the form of sacs with two layers of cells in the walls and an enteron within. The enteron has only one open end—the mouth. Most of the Coelenterates remain fixed to one place. Therefore they have a symmetrically-radial structure.

Questions: 1. What is the structure of the Coral Polyps? 2. What is the body of the Jellyfish like? How does the Jellyfish move? How does it take in food? 3. What are the basic features of the Coelenterates?

Chapter Three

WORMS

§ 8. EARTHWORMS

Habitat. *Earthworms* live in the soil (Fig. 19). The holes leading into their cylindrical homes are often found in the well-manured, friable soil of vegetable and flower gardens, and in compost and manure heaps, where they find plenty of food in the form of rotting organic matter. In such heaps it is easy to find Earthworms even in winter.

Earthworms need oxygen; after heavy rain, when the air has been forced out of the soil by the water, masses of Earthworms burrow out to the surface. This is why they are also called rain-worms.

Oxygen enters their body through the skin. The act of respiration continues as long as the skin is wet. When it gets dry the worm dies.

Having entered its burrow the worm blocks the entrance with earth crumbs. If this does not keep it sufficiently humid, the worm creeps out at night, when the surface is covered with dew, finds a moister place, and burrows another home there.

Bilateral Symmetry. Since the Earthworm spends a major part of its life creeping on the ground, its *ventral side* is somewhat flattened, while the *dorsal surface* is more rounded. The dorsal surface is also darker.

The body of the Earthworm is composed of a series of *segments* which look very much like rings. It is pointed at the anterior and posterior ends, which makes it convenient for the animal to move in both directions. However, the anterior end is muscular and thicker. When burrowing the animal uses it as a driving wedge to separate the particles of soil.

Animals having different anterior and posterior ends and dorsal and ventral sides are said to have developed *bilateral symmetry*. The body of such animals as the Earthworm can be dissected into only two symmetrical, identical parts—left and right.

Fig. 19. Earthworm in its hole.
Right—a closed cocoon (capsule) with an ovum (egg).

Ability to Orientate. The famous British scientist Charles Darwin discovered that Earthworms have the ability to distinguish the leaves they use for food by their fragrance. This means that Earthworms have a sense of smell.

In their skin are organs which react to direct contact. They are called *sensory nerve cells.* Even the slightest disturbance of the soil is sufficient to make the worm creep hastily into its hole. The anterior end of the Earthworm is particularly sensitive: when the animal moves it is the first to come in contact with different objects.

The worm is also known to possess an *organ of taste.*

The eyes are absent but in the skin there are some *light-sensitive cells* ("eyespots"). Worms do not see things but can distinguish between darkness and light. A bright ray of sunlight will immediately send a worm into hiding.

The *sense of hearing* is absent.

Eyesight and hearing are not important for an animal that lives in the soil. That is why they are not developed in Earthworms. But the senses of touch, taste and smell are quite acute, helping them to find food easily, hide from immediate danger, and creep from dry to more favourable places.

Locomotion. The worm's skin is thin and slimy, and conceals two layers of muscular cells. The one nearer the surface is the *circular muscle layer*, which can be seen through the skin. Under it is the *longitudinal muscle layer*, which also consists of cells.

When the circular muscles contract the body of the worm becomes thinner. While the worm grips the ground with the setae (bristles) lining its posterior end it moves the anterior end forward. Then comes the turn of the longitudinal muscles. They contract, and the worm grips the ground with its anterior bristles and draws the posterior section of its body up. The process is repeated again and again, in the same order.

Earthworms and Soil Formation. Earthworms do more than burrow into soil: they "eat" their passage through sucking some of the earth into their body, passing it through the *intestine* and excreting it via the *anus.* In doing so, the animal transforms the organic mat-

ter which is present in the soil into a state more easily assimilated by plants.

Earthworms make the soil friable and mix different layers as they burrow through. They carry tiny particles into the subsoil and bring particles of subsoil to the surface. This deepens the fertile layer of the soil. Charles Darwin compared the work of the Earthworms to that of the plough, and said: "... long before it existed the land was in fact regularly ploughed and still continues to be thus ploughed by Earthworms."

Plants spread their roots along the trenches burrowed by worms; these trenches also facilitate the penetration of water and air into the soil—both of which plants need badly. By taking decayed leaves into their burrows worms increase the humus content of the soil.

The above shows that Earthworms are useful animals which contribute to soil formation and the creation of more favourable conditions for growing plants. Therefore Earthworms must be taken care of and protected.

Questions: 1. What natural conditions are essential for Earthworms? 2. What does the Earthworm look like? What can you say about its symmetry? 3. How does the Earthworm move? 4. What sense organs does it have? Are they well developed? 5. Why do we say that the Earthworm is useful to man?

§ 9. THE STRUCTURE OF EARTHWORMS

Tissues. The Earthworm is a multicellular animal, like the Hydra. The cells, of which its tissues are formed—the *epithelium* (cover tissue) and the muscular and nervous tissues—are also similar in structure and function.

The *epithelium* covers the body protecting it from injury. The cells are very closely bound together, but unlike the epithelial muscular cells of the Hydra, they have no contractile fibres.

The *muscular tissue* consists of tall column-shaped cells whose basic feature is the ability to contract (*contractibility*). The contractions of the muscular cells give rise to movements.

The two characteristic features of the *nervous tissue* are excitability and the ability to pass on stimulation, i.e., conduction.

Body Cavity. Together with the muscles the skin forms a *dermo-muscular cylinder*. Inside the cylinder is the *body cavity* with the intestines (Fig. 20).

The Earthworm's body cavity is subdivided into many sections by thin transverse partitions (septa) which coincide with the grooves between the segments. The segmentation is both external and internal.

Digestive System. The upper side of the *mouth* of the Earthworm is covered by a *lip* (*prostomium*). The worm uses this to seize pieces of decaying leaves. The material then is passed into the muscular *pharynx* and on into the *oesophagus* (Fig. 21).

Past the oesophagus the tube widens into a *crop*, where food is held and moistened before it moves on to the *muscular-walled gizzard* where it is ground up into a pulpy mass and passed into the *intestine.*

The cells of the intestine walls excrete digestive juice the action of which dissolves the food. The dissolved food is absorbed by the walls of the intestine and passes into the blood vessels. The undigested remains are propelled by circular contractions of the intestine towards the anus and excreted. There digestion ends.

Respiration. Oxygen enters the blood through the skin. The blood of the Earthworm is red. The *haemoglobin*, which is dissolved in the blood, plays an important part in transferring oxygen throughout the body. The haemoglobin assimilates oxygen easily and as easily gives it away to the cells.

By means of the circulation of the blood oxygen is fed to all the organs in exchange for carbon dioxide which is excreted through the skin.

Circulatory System. Two blood vessels run the length of the body like thin red threads, one above the intestine known as the *dorsal vessel*, the other under the intestine called the *ventral* (*sub-intestinal*) *vessel.* In the anterior end both vessels meet and are connected by two large circular vessels, the *pseudo-hearts*, so named because of their ability to contract and thereby keep blood circulating.

Blood flows from the dorsal into the ventral vessel. This vessel breaks up into finer branches which reach all the cells. From the blood the cells receive the nutrient matter, without which they cannot live, and oxygen, which is necessary for respiration. In return, the cells excrete harmful fluids and carbon dioxide into the blood.

Flowing through the thinnest epithelial vessels the blood absorbs oxygen and gives off carbon dioxide. The excreted fluids pass from the blood stream into the body cavity.

Excretion. The excretory organs are *nephridia*, of which there are two in almost all the segments. Each *nephridium* looks like a tube. It begins in the body cavity with a fan-shaped funnel and has a narrow exterior opening. The edge of the fan-shaped funnel is bordered

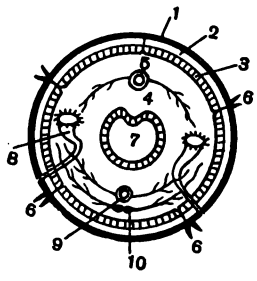

Fig. 20. Cross section of a worm (diagram).
1. Epithelium. *2.* Circular muscle layer. *3.* Longitudinal muscle layer. *4.* Body cavity. *5.* Dorsal blood vessel. *6.* Bristles (setae). *7.* Intestine. *8.* Nephridium. *9.* Ventral vessel. *10.* Ventral nerve cord.

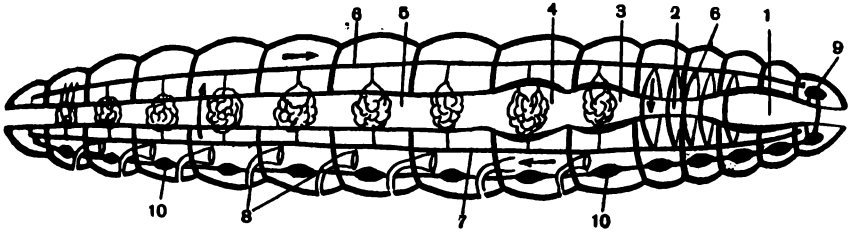

Fig. 21. Longitudinal section of an Earthworm.
1. Pharynx. *2.* Oesophagus. *3.* Crop. *4.* Muscular-walled gizzard. *5.* Intestine. *6.* Dorsal blood vessel and the pseudo-hearts. *7.* Ventral blood vessel. *8.* Nephridia. *9.* Suprapharyngeal ganglion. *10.* Ventral nerve cord.

with cilia. Moving continually, the cilia draw the excreted matter from the body cavity into the nephridia, and pass it out.

Nervous System. Unlike the Hydra which has its nerve cells scattered all over its body, the nerve cells of the Earthworm are joined together to form *ganglia.*

The biggest ganglion lies just above the pharynx and is therefore called *suprapharyngeal ganglion.* It plays the role of a "brain", but a most rudimentary one. Numerous sensory nerves extend forward from it, which explains why the anterior end is so highly sensitive.

The suprapharyngeal ganglion is joined to a *ventral nerve cord ganglion* by a pair of nerve connectives, running down on each side of the pharynx like a collar. This is the *circumpharyngeal nerve belt.* The *ventral nerve cord* runs along the entire body from the ventral ganglion. The ventral cord consists of nerve ganglia joined together to form a chain and lying in pairs in each segment.

The ventral nerve cord gives rise to lateral nerves that branch out to the skin, muscles and intestines whose activity is regulated by the nervous system.

If you touch the skin of the Earthworm with a match the endings of the nerves (Fig. 22) receive an impulse which is sent to the nerve ganglia along the nerves, whence it is carried to the muscles. The muscles react to the stimulation by contracting. As a result, the worm crawls away from the match. This movement caused by the impact of an outside body is known as the *defensive reflex.*

This example shows the role played by the living organism's nervous system in its contacts with the outside world.

Reproduction. Each Earthworm has two kinds of *germ glands*: female —*ovaries,* in which the *ova* (eggs) develop, and male—*testes,* in which *spermatozoa* are stored. The Earthworms are *bisexual,* like the Hydras.

Fertilized eggs develop inside a hard cocoon which forms around the Earthworm's body from fluid thrown out from the *girdle* (*clitel-*

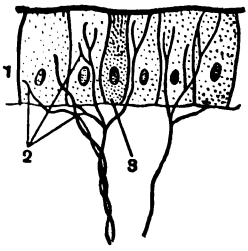

Fig. 22. Nerve endings in the skin of the Earthworm.
1. Epithelial cells.
2. Nerve endings.
3. Mucous gland.

lum), a thick swelling in the anterior end of the worm. Eggs and spermatozoa are discharged into the cocoon and the eggs are fertilized. The worm then pulls itself out of the cocoon. Both ends of the cocoon contract to form a capsule resembling a lemon. The capsule remains in the soil protecting the eggs from dryness and other unfavourable conditions (Fig. 19).

Organs. The organs of digestion are arranged in the following order: mouth, pharynx, oesophagus, crop, muscular-walled gizzard, intestine and anus. This order provides for a gradual transformation of food and its digestion, i.e., the formation of matter which can pass through the walls of the intestine into the blood and can be absorbed by all the cells in the worm's body. All the organs participating in food digestion are united into the *digestive system.*

The *circulatory system* is composed of blood vessels. It is used to circulate blood which carries nutrient matter and dissolved gases.

The nephridia make up the *excretory system*, which helps to remove water and toxic matter formed in the organism of the worm. The excreted fluid can be compared to urine. More highly-developed animals also have a *respiratory system*, which is however absent in Earthworms.

The ventral nerve cord, the circumpharyngeal nerve belt and the nerves are the component parts of the *nervous system.*

Finally, there is also the *reproductive system.*

Questions: 1. What tissues are present in the body of the Earthworm? 2. What organs have been developed? 3. What is understood by the body cavity? 4. How does the Earthworm take food? 5. How does it breathe? 6. How does its blood circulate? 7. How does the Earthworm excrete? 8. Why do we consider it a reflex action when the Earthworm crawls away from a needle?

§ 10. TAPEWORM AND ECHINOCOCCUS

Pork Tapeworm. Structure. A person suffering from Tapeworms complains of discomfort and pain in the intestine and short whitish ribbons are found in the stool.

The *Pork Tapeworm* has a white ribbon-like body commonly reaching about 3 metres in length (Fig. 23). On its anterior end is a rounded *head*, the size of a pin-head, on which are arranged the four *suckers* and two rings of small sharp *hooks* with which it attaches it-

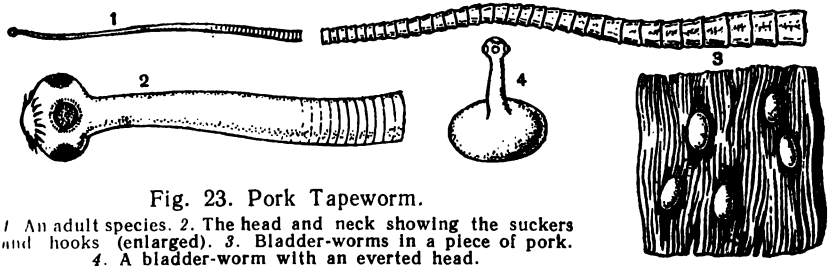

Fig. 23. Pork Tapeworm.
1. An adult species. *2.* The head and neck showing the suckers and hooks (enlarged). *3.* Bladder-worms in a piece of pork. *4.* A bladder-worm with an everted head.

self firmy to the intestines of the host. The head narrows to form a short *neck.* Then comes the ribbon-like *body* subdivided into a great many segments (up to 1,000), called *proglottides.*

A tough *cuticle,* which is unaffected by the action of the host's digestive juices, surrounds the body, enabling the Tapeworm to live in the intestines of its host without being digested along with the food. The Tapeworm absorbs the plentiful food supply around it through the surface of its body. It has no alimentary canal but the reproductive organs are quite well developed. One proglottis contains some 50,000 eggs.

Posterior proglottides loaded with eggs ready for development separate one after another from the free end of the worm's body and are excreted. These segments, which look like short ribbons, are found in the excreta of the host.

The toxic fluids excreted by the Tapeworm gradually produce an adverse effect on the organism of the host.

Life-cycle. A pig burrowing in a heap of refuse may pick up a Tapeworm proglottis full of eggs. The eggs get into the pig's alimentary canal, and there hatch out as *six-hooked embryos.* The embryos use these hooks to bore through the walls of the alimentary canal. They enter the blood vessels in which they are carried around the body until they reach the muscles. Some time later they develop into whitish, semi-transparent *bladder-worms,* the size of an ordinary pea.

Bladder-worms, which may be alive in "underdone", i.e., insufficiently cooked meat, get into the intestine of any person who eats it. The head of the bladder which is inverted, everts. Armed with its suckers and hooks, it clings to the wall of the intestine, absorbs food digested by the host, and growth begins. The bladder itself gradually dissolves while the head begins to bud off one proglottis after another. Within three to four months a complete Tapeworm, 2 to 3 metres long, will have grown.

The Tapeworm can be said to pass through a complicated process of development in the intestines of pigs and human beings.

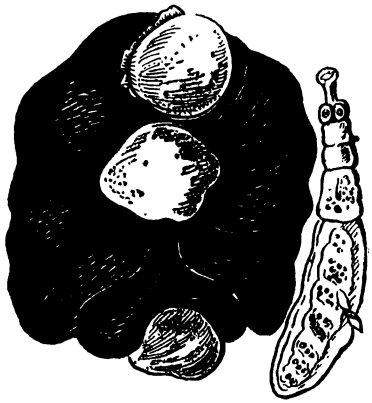

Fig. 24. Echinococcus.
Left—bladder-worms in the liver of an animal (greatly reduced in size); *right*—an adult worm (greatly enlarged).

Animals which exist in other living bodies and derive their nourishment from them are called *parasites.* The body in which they live is their *host.* From this it follows that one living organism can serve as habitat for another.

It is clear from the Tapeworm's life-cycle that it passes various stages of development in both of its hosts—pig and man. Man, in whose intestine the Tapeworm reaches the mature stage of reproduction, is regarded as the *principal* host; the pig is known as the *intermediate host.*

If someone who has a Tapeworm fails to take the necessary sanitary precautions, he may carry some of the parasite's eggs into his mouth. In this way bladder-worms are introduced into one of his organs. If they get into his eyes blindness results; if they attack his brain he will die.

Influence of Parasitic Life. If you compare the structure of a parasite, for instance, a Tapeworm, with a related but independent species, such as the Earthworm, you will notice that the Tapeworm's body is more rudimentary. Some of the vital organs, for example, those which are used for digestion, are absent. On the other hand, others are very prominent (hooks, suckers, tough cuticle). These organs make it possible for the parasite to live at the expense of the host. The tremendous number of eggs passed out in the host's excreta gives the parasite remarkable powers of regeneration and assists in its survival.

Sanitation. When, in the middle of last century, scientists discovered that Tapeworms were introduced into man's intestines in pork, many countries passed health acts requiring that all pork be subjected to strict inspection before being sold to consumers. Whenever bladder-worms were found the pork was pronounced unfit for human consumption and withdrawn from sale. The number of cases of Tapeworm infestation dropped sharply.

Insufficiently cooked or "underdone" meat or fish should not be eaten because of the danger of infestation by some other kinds of Tapeworm.

One of the first signs of infestation is the appearance of the whitish segments of the Tapeworms in the faeces of the host. Medical

treatment is essential to get rid of the parasites. However, care must be taken to ensure that the head has been expelled because if it remains in the host's intestines it will grow new proglottides out from the neck, and the parasite will begin a new life-cycle.

Echinococcus. Man can also obtain harmful worms from dogs. When handling a dog eggs of a small Tapeworm called *Echinococcus* (Fig. 24) may get on his hands and later be swallowed. The Echinococcus lives in the intestines of dogs but its eggs develop in man and also in cattle, the embryos preferring to attach themselves to important organs like the liver. The bladder-worm grows very large, sometimes as big as a child's head. This leads to the destruction of the liver and consequently to the death of the host.

The best way to avoid picking up this parasite is to wash your hands after handling dogs.

Questions: 1. What is the structural difference between the Tapeworm and the Earthworm? 2. What features of the Tapeworm are due to its parasitic existence? 3. Describe the life-cycle of the Tapeworm. How do people get Tapeworms? 4. Why do we say that Tapeworms are harmful? 5. What precautions should be taken against Tapeworm infestation? 6. Why is the Echinococcus harmful?

§ 11. ASCARIS AND PINWORM

Ascaris. Among the other parasitic worms which are harmful to man is the *Ascaris* (Fig. 25), which inhabits small blood vessels in the small intestines. It feeds on semi-digested and digested food, and also sucks blood from the damaged walls of the host's intestines, pressing its lips against the bleeding area.

The Ascaris is lithe and muscular, and normally reaches about 20 cm. in length. It resembles a pencil finely sharpened at both ends. There are no segments, and a cross section has the form of a circle. The worm slowly bends its body to glide easily along in either direction through the semi-fluid food in the intestines.

The body of the Ascaris, like that of the Tapeworm, is encased in a very tough cuticle, which is unaffected by the digestive juices. This cuticle, however, is quite different from that of the free-living worms.

The Ascaris is injurious to man not only because it robs him of part of his food and sucks his blood, but also because it excretes a highly toxic substance that gradually poisons its host. Various pathogenic bacteria can gain entry into man's blood through the ulcers inflicted by the Ascaris on the walls of the intestines. The presence of a great number of these worms may block the intestines and even cause death.

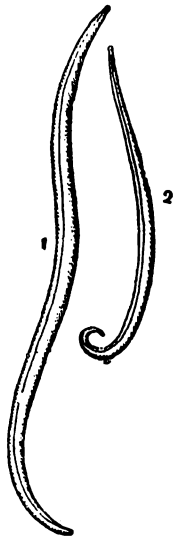

Fig. 25. Ascaris (the Common Roundworm).
1. Female. *2*. Male.

The Ascaris reproduces at a tremendous rate, one female producing 200,000 eggs a day. The eggs are very small and protected by a thick shell. Such great numbers are necessary for the animal to survive, because most of the eggs do not reach the intestines of a host but perish on the way. If the Ascaris were not so fertile it would have died out long ago.

The eggs are passed out of the intestines of man in the faeces. After a time in the air (oxygen-filled medium) they develop embryos. If you eat unwashed vegetables or berries, grown on plots fertilized with human excreta, you may be unfortunate enough to swallow some Ascaris eggs with developed embryos in them. Eggs may also be introduced by dirty hands.

Flies play a definite role in spreading infestation. Visiting all sorts of places, including lavatories, they pick up Ascaris eggs and carry them on their legs (Fig. 26) everywhere—to markets, homes, shops, canteens. They leave the eggs on the foodstuffs on which they alight.

The disease caused by the presence of the Ascaris in the human body is known as *ascariasis*. It mostly affects children, who grow pale and inert, complain of intestinal pain, study with great difficulty, and are very restless during sleep, often grinding their teeth. Adults suffer from depression, lowered capacity for work and inertness.

Children who are not kept clean contribute greatly to the spread of the ascariasis among adult members of the family. It has been noticed that children who wash their hands before meals, keep their bodies, underwear and clothes neat and clean, do not live in dirty apartments, never eat unwashed fruit or vegetables, and help protect foodstuffs from flies—never get Ascaris worms.

Ascariasis is detected by the thorough examination of faeces under a microscope. The doctor will prescribe medicine to get rid of the worms.

Pinworm. *Pinworms* are white and very small (between 5 and 8 mm.). They live in children's intestines and resemble miniature Ascaris.

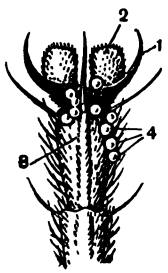

Fig. 26. A fly's leg carrying Ascaris eggs.
1. Claw. *2*. Sucker. *3*. Segment. *4*. Ascaris eggs.

At night they crawl out and cause itchiness in the region of the anus. The child, sleepy and annoyed, scratches the itchy place, gathering a lot of Pinworm eggs under his nails. Next morning he may forget to wash his hands before eating his breakfast. If he also has the bad habit of biting his nails, the eggs will get into his mouth and pass into his intestines.

Children with unclean habits become a source of constant self-infection by parasitic Pinworms. They can also infect other people.

Questions: 1. Why is the Ascaris harmful? 2. How do people become infected with these worms? 3. What measures can be taken to prevent infestation by Ascaris and Pinworms?

§ 12. WORMS MAY CAUSE SERIOUS DAMAGE TO AGRICULTURE AND STOCK

Many parasitic worms, living in the intestines, lungs, blood, bones and even brains of animals, cause great damage to the cattle, fishing and hunting industries. Some cause the death of many animals, especially young ones; others reduce milk yields and rates of growth, and cause deterioration in the quality of meat and wool. Among the most dangerous parasitic worms are Brainworms and Liver and Lung Flukes.

Brainworm. The eggs of this parasitic worm (Fig. 27) which is found in dogs, wolves and foxes, are passed out onto pastures in the excreta of the animals. If the eggs are subsequently swallowed by grazing sheep, large-sized watery bladders containing multitudes of worm heads will develop in the brains of the sheep, causing increasing pressure as they grow. As a result, the sheep develop *turnsickness:* they circle in one place until they die. If a wolf or some other wild beast eats the head of the infected sheep, the Brainworms enter its intestines and begin a new life-cycle there.

Lung Flukes. These internal parasites (Fig. 28) are a serious menace to cattle, especially calves and sheep. In appearance they resemble pieces of thick, tangled threads. When large numbers of them get into the windpipe and lungs of an animal, it begins to cough, loses strength and weight, and may eventually die.

Infection takes place while pasturing on grass contaminated by the excreta of sick animals.

Liver Fluke. The *Liver Fluke* which inhabits the livers of cattle and sheep is a very harmful parasite

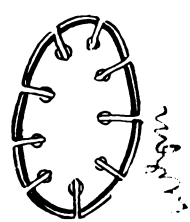

Fig. 27. The bladder of a sheep Brainworm (diagram).

Fig. 28. Lung Flukes.

Fig. 29. Liver Fluke.
1. Oral sucker, 2. Ventral sucker.

(Fig. 29). By blocking the liver ducts it causes disturbances in the functional cycle of the liver, the vital organ, and poisons the host by producing a highly toxic substance. All this retards growth and causes the milk yield to fall.

The eggs having been dropped into a pond, in the host's excreta, ciliated larvae (miricidia) are hatched out. The larva swims about actively and then enters the body of the small mud-snail, which acts as the intermediate host. Within the snail's body the larva undergoes a complicated process, giving rise to a new generation of embryonic cells which develop into small worms (cercariae). The cercariae leave the body of the snail, swim about in the water, settle on plants and encyst. Should the water level fall and the plants become exposed, they may be eaten by cattle which will then become infested with liver flukes.

Sugar-beet Eelworm. Cultivated plants may be damaged greatly by *Nematodes*. One of them, the *Sugar-beet Eelworm*, which attacks the roots of sugar-beet, is especially harmful. It causes swellings to appear and the development of a great many superfluous roots. The yield drops and the sugar content decreases.

Questions: 1. What are the principal and intermediate hosts of the Brain-worm? 2. How do animals become infested with Lung and Liver Flukes? 3. Which worms present the greatest danger to crops and how do they damage them?

§ 13. CONTROL MEASURES IN THE USSR

Protection of the Population. The Government of the Soviet Union allocates considerable sums to the study of parasitic worms. A new branch of zoology, *helminthology*, has sprung up largely as a result of research conducted by Soviet experts. The contribution made by Academician K. I. Skryabin has been particularly important. Studying the life-history, relationships and functional systems of the parasites, helminthologists have revealed the causes of much suffering to people and animals.

Research has made it possible to launch a large-scale drive to eradicate parasitic worms. Talks have been given at schools, nursery schools and crèches, and to the adult population on measures to prevent infestment by worms. Systematic medical check-ups of children have been held. Many schools and nursery schools have arranged for

the children attending them to take anti-Ascaris drugs once a year.

The cooking at canteens and restaurants and the storage of foodstuffs in shops are under medical supervision. From time to time there are sanitary check-ups of homes, rubbish chutes and lavatories. The rate of infestation has been reduced by these measures. In a number of regions some of the parasitic worms have been almost completely eradicated.

Academician K. I. Skryabin.

Nevertheless, it cannot be said that parasitic worms have ceased to be a health problem. Control measures have to be continued. People who are careless, or too shy to admit infection, suffer themselves and are a menace to others.

Anaemia, lack of appetite, intestinal pain and inertness are symptoms which should make a person seek immediate medical advice. Attempts to treat oneself may prolong the condition. Medical advice should be sought. The medicines prescribed by the doctor should be taken only as directed. It is very important to adhere to the doses which have been indicated. If the dose taken is insufficient the parasites will become accustomed to the drug and the poison will prove less effective. Over-dosage may poison the patient.

Protection of Plants. It has been scientifically established that certain types of parasitic worms feed on definite species of the animal and plant kingdoms. Sugar-beet Eelworms, for example, can only live on the roots of cruciferous and goosefoot plants (members of the same family). One of the ways to eradicate Eelworms therefore is to rotate the planting of beet with cereals or legumes.

The damage caused by turnsickness was very grave until the shepherds prevented their dogs from eating dead sheep. Previously, while devouring parts of the worm-infested sheep, the dogs swallowed Brainworm bladders and served as principal hosts. The loss of sheep due to turnsickness has decreased radically since the enforcement of regulations prohibiting the use of infected sheep as dog food.

Control measures to eradicate parasitic worms in animal husbandry are carried out in the Soviet Union under the guidance of Academician K. I. Skryabin and his research associates. They have suggested rotation of pastures as one of the ways of preventing contamination by Lung and Liver Flukes. New medical preparations and methods of treatment have also been evolved.

Today, nearly all the state and collective farms in the country have veterinary surgeons on their staffs. This is very important for a planned, nationwide drive to wipe out worms which injure animal husbandry.

Conclusion. Despite considerable structural variations, worms have many common features: an elongated body, no legs and no hard skeleton.

As compared with the Hydra, worms have a more complex structure. Therefore, it can be presumed that they appeared on the Earth later than the coelenterates.

Depending on their specific structural features, worms are divided into several groups. Earthworms belong to the *Segmented Worms* (*Annelids*). Ascaris, Lung Flukes, Pinworms and Sugar-beet Eelworms are called *Roundworms* (*Nematodes*). Pork Tapeworms, Liver Flukes, Echinococcus and Brainworms are known as *Flatworms* (*Platyhelminthes*).

Questions: 1. What is being done in the USSR to prevent people being infected with parasitic worms? 2. What measures are taken to protect domestic animals? 3. What features are common to all worms? Into how many groups are they divided?

MALACOZOANS OR MOLLUSCS

§ 14. PEARL MUSSEL

Natural History and Behaviour. *Pearl Mussel* (Fig. 30) is the common name of an animal which has a hard shell that is divided into two parts. The Pearl Mussel lives on the sand-banks of rivers and in river beds. It spends most of its life half-buried in the mud usually fixed to one spot; when it occasionally changes its position, it slowly ploughs its way along, leaving a deep furrow in its wake.

The water flowing past washes the oblong shell and supplies the animal with oxygen and its food — tiny organisms and decaying organic matter.

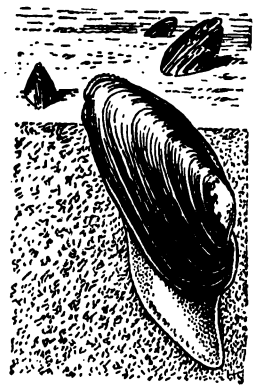

Fig. 30. Pearl Mussel lying in a river bed.

The Shell. The bodies of the Pearl Mussel and of all the other molluscs are soft. They have no rigid skeleton. This explains the name "*mollusc*", which is derived from a Latin word ("molluscus") meaning "*soft*".

The body is protected by a hard *shell* composed of two *valves*. The valves are joined together by a pair of transverse *muscles* (anterior and posterior "*adductors*"). When the adductors contract the valves close.

The valves are opened by means of a *hinge ligament*, which connects them at the posterior end. As soon as the "adductors" relax, the hinge separates one valve from the other.

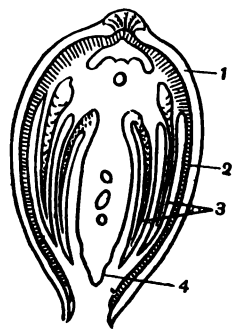

Fig. 31. A cross section of the Pearl Mussel's body.
1. Shell. *2*. Mantle. *3*. Gills. *4*. Foot.

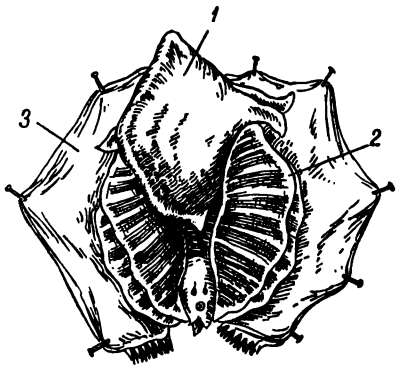

Fig. 32. The body of a Pearl Mussel opened out (bottom view).
1. Foot. *2*. Gills. *3*. Mantle.

Distributed along the dorsal border of the valves is a system of hard, interlocking *ribs* and *teeth*. Their function is to make the contraction quite firm.

The shell consists of three layers. The outer *horny layer* is dark, matching the colour of the ground on which the animal rests most of the time. In summer the shell grows faster than in winter. Therefore, summer growth-lines are wider apart than winter ones.

In the middle is the white, opaque *calcareous layer*. The third layer is built up of *nacre* or *mother-of-pearl*, and is beautifully irridescent. The calcareous and nacre layers result from the deposition of hard limy substances. The shell provides reliable protection and a solid base for the soft body of the Pearl Mussel.

The shell may be regarded as the *exoskeleton* of the mollusc.

The Mantle. The shell is built by a fold of membrane hanging on both sides from the back of the animal's body. This is called the *mantle* and is a characteristic organ of the mollusc. The right and left halves fit the valves of the shell closely. Along the outer edge of the mantle, owing to the continual secretion from it, there is a constant increase in the size of the horny, calcareous and nacre layers.

The Foot. The Pearl Mussel moves about by means of a broad, flat foot attached to the underside of its body. This foot protrudes between the valves and is anchored in the sand almost all the time. Separating the particles of the ground the foot acts like a wedge. It contracts its muscles, and so draws the rest of the body forward.

Respiration. The space between the body of the mussel and the mantle is known as the *mantle cavity*. There, on either side of the body and above the foot, are the *gills*, two dark-brown plates with transverse stripes. The gills perform the function of respiratory organs, absorbing oxygen which is dissolved in the water.

The gills are covered with a great number of tiny *cilia*. Owing to the action of the cilia, a current of water is continually drawn in and thrust out.

Water flows into the mantle cavity through a narrow posterior orifice bordered by the soft, slimy mantle fringe. This orifice is called the *lower* (*ventral*) or *inhalant siphon*. The other orifice, situated above the first, is called the *upper* (*dorsal*) or *exhalant siphon*. Water

flows through the gills, bringing dissolved oxygen and removing carbon dioxide.

Nutrition. Particles of plant and animal matter float into the mantle cavity with the inflowing water. The movements of the cilia direct them to the *lips* and the *mouth*.

Internal Organisation. The Pearl Mussel, like the Earthworm, has *organs of digestion, a blood circulatory system* and *organs of excretion* and *reproduction*, the activity of which is regulated by the *nervous system*. The nerve centres continually react to impulses from outside. You will see proof of this if you force a thin twig between the valves of the shell. The Pearl Mussel will react to the irritation by pressing the parts of its shell so tightly together that you will be able to pull it out of the water with the twig.

Questions: 1. What are the specific structural features of the Pearl Mussel? 2. How does a Pearl Mussel move? 3. How does it breathe? 4. How does it take food? 5. What is the role of the mantle? 6. Why is the shell so important? 7. How does a Pearl Mussel react to external stimulation?

§ 15. MOLLUSCS AND THE DAMAGE THEY DO TO AGRICULTURE

Roman Snail. The *Roman Snail* is a land animal (Fig. 33). In the Soviet Union it is restricted to the southern regions, and is mostly found on vines and fruit-trees. Its *shell* is considerably thinner than that of the Pearl Mussel, and has the shape of a spiral cone. It is active in the warmer and moister seasons of the year. It creeps slowly about the trunks and leaves of the trees by extending the anterior end and lower (ventral) surface of its body (known as the *foot*). The functions of the foot are carried out by the visceral mass (belly), therefore snails are classified as Gastropods ("gaster" —belly; "podos"—foot).

At the anterior end of the snail are a mouth and two pairs of *horns*, or *tentacles*, a short and a long one. The shorter tentacles act as feelers and also to scent food; on the extremity of each of the longer ones is a black dot—the *eye*. The snail is very "short-sighted". Because of its nocturnal habits, it cannot distinguish colours: everything looks grey. If you watch a creeping snail you will notice a small opening under the right edge of its shell, the *pneumostome*, which allows

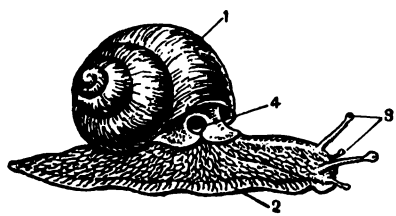

Fig. 33. Roman Snail.
1. Shell. *2*. Foot. *3*. Horns (tentacles). *4*. Pneumostome.

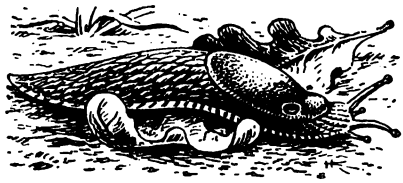

Fig. 34. Grey Slug.

air to be admitted to the mantle cavity. When the cavity contracts the air is pushed out (exhaled). Consequently, it can be said that the mantle cavity performs the function of a breathing organ, a *lung*.

In the snail's mouth is a tongue-like organ, the *radula*. It is equipped with several rows of sharp, strong teeth with which it eats into leaves. Destroying grapevines and leaves, the snail does great damage to plants.

When the air becomes very dry and there is strong sunlight, the Roman Snail attaches itself firmly to a tree trunk. It retreats into its shell and secretes a temporary lid to seal itself off from the outside world. The lid is composed of slime and hardens on contact with the air. A period of summer slumber ensues. The same process is repeated in winter (hibernation).

One way to combat snails is to pick them off the trees when they hibernate. It is also possible to spray the plants with lethal poisons. Having eaten chemically-treated leaves, the snail dies.

The Grey Slug. *Grey Slugs* also seriously damage garden plants and crops (Fig. 34). In late summer representatives of this group of molluscs are often seen on edible mushrooms—rough-stemmed boletus, boletus versipellus, etc. They leave deep grooves where they eat into the mushrooms. In autumn they invade grain fields and vegetable gardens to feed on the young tender shoots of the winter crops and maturing cabbages. Some of them live through the winter, and can be found in early spring.

Pick up a slug and place it on a glass plate. Watch it for some time. When disturbed it lies like a shapeless ball. Gradually, however, the horn-like *tentacles* emerge at its anterior end, it stretches its body and starts crawling along the plate.

When the slug moves its body is elongated and somewhat flattened towards the tail. Like the snail it has a pair of long tentacles and another pair of short ones. The ends of the longer tentacles carry the eyes. Slugs distinguish objects at short distances, but are "colour-blind". The shorter tentacles act as feelers, palpating objects and food.

The slug is able to move around by means of its foot, i.e., the broad visceral mass of its body. If you watch the movements of the foot through a glass plate from below

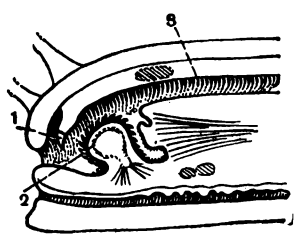

Fig. 35. The mouth of a slug.
1. Upper jaw armed with a tooth. *2*. Radula. *3*. Alimentary canal.

when the animal is crawling, you will see wave-like muscular contractions. These contractions allow the slug to glide smoothly along the surface of the plate. You will also notice that it leaves a thread of slime behind it. The slime is secreted by the skin.

At the dorsal anterior end of its body the slug has a small growth of skin. This is a remnant of the *mantle*. An oval *pneumostome*, leading into the mantle cavity, is situated on its right side. The mantle cavity performs the functions of the *lung*: the slug takes in air. Hidden in the growth of skin is a small remnant of a *shell*.

The *mouth opening* is on the ventral side of the anterior end. The tongue is like a ribbon covered with rows of small, strong teeth. The tongue is called a radula (Fig. 35). With this organ the slug eats into leaves, boring holes and depressions in them.

The slug is protected from excessive dehydration by a thick layer of slime. When the air is dry and the weather hot, slugs hide under logs, boards, or stones, coming out as darkness falls to search for food. In the autumn the animal deposits small clusters of eggs in moist soil under boards or stones, or some other shelter. The eggs are ball-shaped, greenish, semi-transparent, and the size of a pin-head. It is not difficult to find them in the vegetable or flower gardens in spring or autumn under different objects, some of which have been mentioned above.

Slugs increase especially rapidly when the summer is wet and warm, and the autumn is long. In such seasons they can cause very serious damage.

To combat slugs dust the places where they conceal themselves during the day and where they lay their eggs with superphosphate or freshly-slaked lime. On contacting the skin of the slugs these substances give rise to ulcers, and the animals die. Different models of dusting machines can be used for this purpose.

Conclusion. If you compare a Pearl Mussel, a Snail and a Slug, you will notice that they are similar in structure. Their bodies are *soft* and *unsegmented*. They have a *shell* (sometimes only a remnant), a *mantle*, and a *foot*. Since the body structure of these animals is more complex than that of the worm they must have made their appearance on the surface of our planet at a later period than it did. Molluscs mostly live in the sea. Many are edible, or can be used as fish bait or food for aquatic fowl and other birds and animals hunted by man.

Questions: 1. What is the difference between the Roman Snail and the Grey Slug on the one hand and the Pearl Mussel on the other? 2. How does one combat snails and slugs? 3. In what way are molluscs harmful? 4. What are the typical features of the molluscs?

Chapter Five

ARTHROPODA

§ 16. MAY-BEETLE. EXTERNAL FEATURES.

Habits. May-beetles appear in spring, in the month of May. During the day they hide among the leaves of trees, mostly birches and oaks.

May-beetles are vegetable-eaters. When darkness falls a slight buzzing sound can be heard as scores of them circle over the tree tops, creep along the branches, and feed on leaves. But as dawn approaches, and it becomes chilly, they seek refuge in the trees. Shake the branches and May-beetles fall like apples to the ground.

Structure. The beetle's body consists of three clearly distinct sections—*head*, *thorax*, and *abdomen* (Fig. 36).

The head carries a pair of feelers (antennae), the eyes and the mouth-parts.

The thorax is composed of three segments and bears three pairs of legs and a pair of hard forewings (elytra) which enclose the two membranous hindwings—the organs of flight.

On each side of the segmented abdomen are small oval openings, or *spiracles*, used for breathing. The body terminates with the anus.

Locomotion. Beetles have three pairs of segmented (jointed) legs, growing out of the thorax. Hence the name *arthropods*, meaning "jointed limb". All insects related to the May-beetle have these and are therefore classified as arthropods.

The two pairs of wings, the *forewings*, which are hard, and the membranous *hindwings*, are also used as means of locomotion. When preparing to fly, the beetle lifts its forewings and spreads its hind-wings. Then, with its three pairs of legs stretched forward, it rises aloft rather clumsily, producing a loud buzzing noise.

Orientation. Orientation in its natural environment is achieved by means of the nervous system and the organs of sense.

The *eyes* of the beetle are compound, made up of a large number of separate units, or ommatidia (Fig. 37). Each unit can see only that part of the object or image that is directly opposite it. The objects are therefore perceived "piecemeal" and have to be "rebuilt" into one whole. The eyes are not big and can only distinguish things at short distances.

The *feelers* (*antennae*) which serve as the organs of smell are black, with plates which form tiny fans. In the female the feelers consist of 6 plates and are short; in the male they are longer and have 7 plates. These feelers enable beetles to scent food a considerable distance away.

Having landed on a tree the beetle begins to run about the leaves touching them with the *palps*, segmented appendages to its mouth-parts, which serve as the organs of *touch*.

External Cover. The May-beetle differs from the worm and the mollusc in having a hard external cuticle. This is composed of a substance known as *chitin*, which is excreted by the skin cells. The *cuticle* serves as a protective armour.

Where the segments join, the cuticle is thin and flexible, allowing the beetle to move its head, thorax, abdomen, legs, feelers and palps.

The cuticle is not only a protective armour, it also serves as an *exoskeleton*, to which the muscles are attached. A fish, for instance, has its skeleton inside its body, enveloped by muscles; but the beetle's muscles are hidden under the exoskeleton, being attached to it from the inside. However, different sections of the beetle's skeleton and body, as well as the legs, are set into motion in the same way as those of the fish: by muscular contraction.

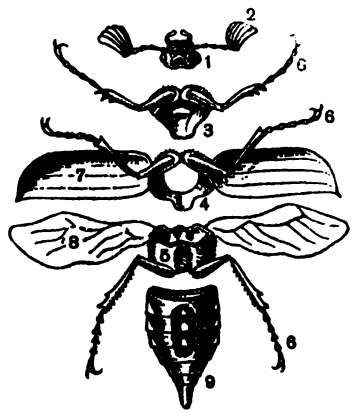

Fig. 36. Dissection of a May-beetle.

1. Head. *2*. Feelers (antennae). *3*. Prothorax. *4*. Mesothorax. *5*. Metathorax. *6*. Legs. *7*. Forewings (elytra). *8*. Membranous hindwings. *9*. Abdomen.

Nutrition. The beetle takes a leaf between its legs which end in claws, and bites off a piece with its jaws.

The *jaws*, two hard, toothed plates, are found on each side of its mouth.

Fig. 37. The compound eye of an insect (microscopic view).

Right—a part incision; *bottom*—the fibres of the optic nerve and the branching tracheae.

By alternately bringing the jaws together and pulling them apart the beetle draws the leaf in, biting off one piece after another.

The *upper* and *lower lips* hold the food, which is immediately swallowed.

The beetle is unable to chew, therefore quite large pieces of leaves enter the intestine.

Questions: 1. What are the structural differences between the May-beetle and the animals you studied earlier? 2. What are the different parts of the beetle's body? 3. How does the beetle move? 4. What organs help the beetle to orientate itself in its natural environment? 5. What does the May-beetle feed on? 6. What is the role of its chitinous cuticle?

§ 17. INTERNAL ANATOMY

Digestive System. The pieces of leaves bitten off by the beetle pass through the *pharynx* (Fig. 38) into the *oesophagus*, where they come in contact with saliva. From the oesophagus they pass, in small portions, into the *muscular*, or *masticatory*, gizzard, which is lined with toothed chitinous plates. The plates grind the pieces of food in a process that resembles chewing.

Then comes the *mesenteron* which has glandular walls that secrete digestive juices. Under the influence of these juices the food is digested, or dissolved. The mesenteron is the beetle's *digestive region*. The digested food is absorbed by the walls.

The waste products enter the *rectum*, accumulate, and are periodically excreted through the anus.

Respiratory System. The beetle's respiratory system is very interesting. The oxygen is taken direct to the various parts of the body through narrow openings (spiracles), each of which communicates with a thin tube, a *trachea* (Fig. 39). The tracheae are lined with spiral chitinous threads which support the walls and prevent the tubes from collapsing. The tracheae form a ramified network, branching out into all parts of the body—to the eyes, feelers, legs, etc. This system provides for the free access of air to all the tissues.

If you watch a beetle you will notice that regular changes take place in the size of the abdomen—it alternately expands and contracts. Respiration is taking place. When the abdomen expands, oxygen-filled air flows into the tracheae through the spiracles. The beetle is inhaling. When the abdomen contracts, air laden with carbon dioxide is pushed out of the tracheae through the spiracles. The beetle is exhaling.

At the end of some of the tracheae are *air-sacs*, not lined with chitinous threads. The air-sacs enlarge reducing the beetle's

body-weight and making flight easier.

Circulatory System. Oxygen is distributed to the tissues through the tracheae. Carbon dioxide is taken out in the same way. The blood does not carry the gases. The blood bathes the tissues in nutritive substances which it receives from the intestine.

The circulatory system consists of the heart and the aorta (Fig. 40). Circulation is achieved by the contractions of the tubular *heart*, which lies in the dorsal side of the body and is divided into a number of separate chambers. Each has two openings (ostia), one on either side. The anterior end of the heart opens into the *aorta*; the opposite end is closed. When the heart expands, blood flows in from the body cavity through the openings (ostia) in the chamber walls. When it contracts, the ostia are shut and the blood is channelled into the aorta, whence it proceeds to fill the space between the various organs. The beetle has an *open* circulatory system.

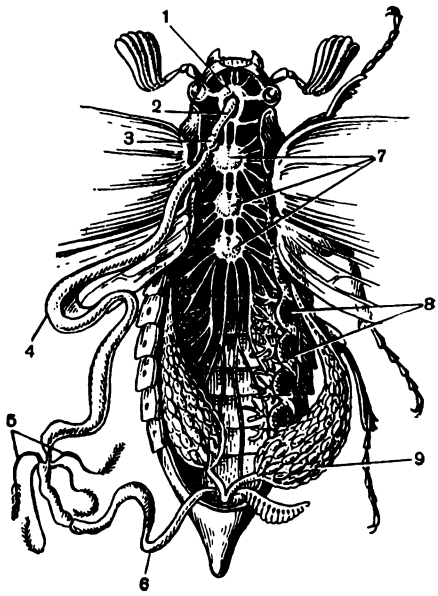

Fig. 38. The internal anatomy of the May-beetle.

1. The supraoesophageal ganglion. *2*. Oesophagus. *3*. Gizzard. *4*. Mesenteron, the digestive region. *5*. Excretory tubules. *6*. Rectum. *7*. Ventral nerve cord. *8*. Tracheae. *9*. Ovaries filled with ova (eggs).

Excretory System. The excretion of fluids harmful to the organism takes place through thin *excretory tubules*. One end of each opens directly into the intestine between the mesenteron and the rectum. The opposite end is blind, and lies in the body cavity.

The blood carries waste products from the tissues to the body cavity, where they penetrate into the tubules through their walls, pass into the intestine, and are excreted.

Nervous System. The nervous system of the May-beetle is made up of the *supraoesophageal ganglion*, the *circumoesophageal commissures*, and the *ventral nerve cord*.

The *nerve ganglia* in the beetle, unlike those in the Earthworm, are not distributed evenly along the entire length of the animal's body. They are fused into three large ganglia in the thorax. As a result of quite well-developed sense organs, the supraoesophageal

Fig. 39. Tracheae (microscopic view).

ganglion has achieved especially prominent dimensions and plays the role of a brain.

When the wind carries the scent of some food (for example, birch-tree leaves) to the beetle, this external stimulation influences the *sensory cells* in the beetle's antennae. The dendrites of the cells convey the impulse to the supraoesophageal ganglion, in other words, the brain, whence it is sent to the nerve ganglia in the thorax, from which *nerves* go out to the muscles controlling the forewings and membranous hindwings. As soon as the impulse reaches them the muscles contract, the beetle raises its forewings, spreads its hindwings, and flies in the direction of the scent. The impulse to fly was caused by the *food reflex*. The stimulus came from the scent of the leaves.

Fig. 40. The heart of the May-beetle.
1. Aorta. *2*. Chambers. *3*. Muscles.

A beetle is able to find a solitary birch-tree more than a mile away.

When the beetle flies both wings work together. When it runs, it raises its legs in turn. The slightest injury to the nervous system is enough to cause the established order to be disturbed. The nervous system of insects ensures the coordinated activity of all their organs.

Insects. Characters. The May-beetle is a typical representative of the Arthropoda. Its body is lined with chitin, its legs have joints.

The May-beetle is an insect. Insects, one of the groups of the Arthropoda, have the following features in common:

a head, a thorax, and an abdomen;
three pairs of legs;
a pair of well-developed antennae;
compound eyes (most of them);
respiratory organs made up of tracheae;
wings (the overwhelming majority).

Insects form the most numerous group among the Arthropoda.

Questions: 1. How does the May-beetle digest food? 2. How does it breathe? 3. What is its circulatory system like? 4. How does it excrete? 5. What is the role of its nervous system? 6. Why do we say that the May-beetle is somewhat better developed than the Earthworm?

Reproductive System. The sexes are separate. The female has *ovaries*. Each ovary has many thin-walled tubes full of semi-transparent eggs. The male organs are the *testes*—two long, white, coiled tubules—which carry sperms.

Egg-laying. Soon after mating, the male beetles die. The females eat their fill of leaves, and then find some young pines growing on sand. (They are attracted by the pleasant fragrance and the warmth of the friable soil.) They deposit their eggs in the soil in several pods. The eggs are no bigger than hemp seeds.

Development. The eggs hatch out into white *larvae* which look somewhat like worms but have a chitinous cuticle, segmented legs, strong thick-set jaws, and clearly visible spiracles. The wings and eyes, so well developed in the adult beetle, are absent. The larvae feed on the roots of young pine-trees, inflicting great damage.

Every year a pine-tree adds another ring to its trunk. (Count the rings to find out the age of a tree.) However, not infrequently, one comes across specimens having the same numbers of rings but differing in height. The roots of the trees that have failed to develop have most likely been attacked by May-beetle larvae.

You may notice yellow, dead specimens among healthy, green saplings. Give them a gentle tug, and they will yield at once for their roots have no hold. Look into the hole, and most probably you will find May-beetle grubs, as the larvae are sometimes called.

In the south, the pest does great damage to sugar-beet and other crops.

As the larvae grow they shed their skins or *moult*. A new skin is secreted just before the *moulting* process begins. Before it hardens, the new skin is soft and thin, and can stretch, allowing the young grub to grow.

After five moultings the larva becomes a *pupa*, which resembles an adult beetle and has noticeable rudimentary wings, antennae, and other organs. The pupa undergoes a period of complete rest when it lies quite inactive in the earth (does not take food and does not grow). In fact, immense biological changes are going on in preparation for the transformation into an adult beetle. Throughout the pupation period the young insect lives on the nutritive substances stored up during the larval stage.

Some time later the pupa develops into an *adult beetle*, but does not emerge from the soil until the end of the winter.

Next spring the perfectly formed beetle comes up to the surface. It does not have to moult or grow.

Consequently, the life-cycle of a beetle involves a complex *metamorphosis.* The insect passes through four stages: ovum, larva, pupa, adult beetle. *Complete* metamorphosis is the name given to these four stages. The May-beetle belongs to the group of insects that develop in this manner. Depending on the natural environment (climate) and the food available, complete metamorphosis may vary from three years in the south to five years in the northern regions of the USSR.

It has been noticed that beetles become most numerous at certain periods. (In the temperate zone of the USSR every four years.)

Insect Pests. May-beetles, especially the larvae which attack the roots of young pine-trees, inflict great damage to forests. Special care must be taken to protect the afforestation belts in the south.

An effective method of controlling May-beetles is to destroy the adults. In the early morning stretch a length of tarpaulin under a tree and shake the branches. The insects, numbed by the cold, will fall. Collect them and pour boiling water over them. They can then be fed to poultry, or pigs. As they contain a considerable amount of protein and fat, they make useful fodder. It is also a good idea to store up beetles for winter feed. The beetles must be dried and ground into powder. The powder can be added to the fodder of domestic animals. In this way the harmful insects can at least be of some use.

Another control method is to carry out aerial dusting of beetle-infested forests with toxic chemicals (insecticides) from planes. The beetles die after devouring the poisoned leaves.

Larvae can be destroyed by introducing toxic chemicals into the soil.

Questions: 1. Can you describe the life-cycle of the May-beetle? 2. What damage is done by the May-beetles at the larval stage? As adult insects? 3. What are the most effective methods of controlling them?

§ 19. FOREST PESTS

(Text for reading before an insect-hunting excursion to the woods)

Primary Pests. May-beetles are not the only insect pests that attack forests. There are several other species which either damage healthy trees (*primary pests*) or settle as parasites on those that have been retarded in their development (*secondary pests*).

The Siberian Cedar Moth (Dendrolius Sibirius) is an example of a serious primary pest, a dangerous enemy of coniferous forests (Fig. 41).

Extensive reproduction sometimes results in shocking devastation in the forest regions of the Far East, Siberia, the Urals, and Bashkiria. The huge numbers of caterpillars devour the needles of cedars, pines, larches, balsam and ordinary firs.

A formidable invasion of Siberian Cedar Moths occurred between the Ob and the Enisei during the fifties. The trees were stripped bare and finally the caterpillars died from lack of food. Nearly 8,000,000 hectares of forest were destroyed. This meant more than the loss of the timber. Squirrel, sable, and other fur-bearing animals left the area, and the birds migrated to more favourable habitats. The harvests of cedar nuts went down drastically. Gradually, the area was reverting to swampland.

The Cedar Moths were able to reproduce so rapidly not only because the taiga wilderness provided an ideal natural environment and human settlements were scarce, but because the local population was unaware of the damage this moth could inflict. Control measures were taken when it was much too late, i.e., when the caterpillars had begun to die out. To prevent such calamities citizens should be educated to recognise the most harmful insects and taught how to take adequate control measures against them.

The *Siberian Cedar Moth* is a large insect that flies at night. Its wings are grey, the front pair each having a single white spot.

The flying period begins in July and continues into August, when the females lay their pale-green eggs, the size of a pin-head, on the tree needles.

When the *caterpillars* hatch out they bear no resemblance to adult moths and are more like worms. However, the presence of a chitin exoskeleton, mouth-parts and spiracles provides unmistakable evidence that they are insects. The second and third segments are patterned with transverse black-blue stripes.

In their first year caterpillars grow fast and moult twice. They spend late autumn and winter hibernating in the soil. The following summer is devoted to excessive feeding, and then, after the fifth moulting is over, they hibernate again, till spring. The greatest damage is inflicted by caterpillars which have reached the final stage: the end of the second summer or the early part of the third.

Fig. 41. Siberian Cedar Moth.
1. Adult insect. *2.* Caterpillar. *3.* Cocoon. *4.* Ova (eggs).

After its second period of hibernation the caterpillar spins a *cocoon* in which to pupate, and hangs it either on a branch or a tree trunk. Growth is completed by July or August, when the adult moth emerges.

Scientists having described the life-cycle of the Siberian Cedar Moth, it has become possible to find effective control methods.

Small groves can be protected by placing grease bands around each tree. The caterpillars are caught climbing up the tree trunks in search of food after their winter hibernation in the soil.

Caterpillars and cocoons can also be collected by hand. Larger tracts of forest can be dusted with insecticides from planes.

E. V. Talalayev, a scientist from Irkutsk, has discovered a bacterium which causes putrefaction of the blood of the Siberian Cedar Moth caterpillars. At present it is being used extensively to control the pest throughout the Siberian taiga. Bacterial "warfare" has proved cheaper and more effective than toxic chemicals.

The greatest danger to pine forests in the European part of the Soviet Union is the *Pine Moth.* You can easily find its large, hairy caterpillars—either dark-brown or silvery-grey in colour, if you go on an excursion in spring. They are commonly found on pine-trees, and sometimes on firs and larches.

The group of primary pests includes many more insects, which feed on foliage and coniferous trees, and destroy young shoots.

Secondary Pests. The caterpillars of the Siberian Cedar Moth and other primary pests are followed by secondary pests, for instance, the *Longhorn Beetles* (Fig. 42), which attack already weakened trees.

Large, white and worm-like, the larva of the Longhorn Beetle bores fast through living wood and causes incalculable damage by spoiling the quality of the timber: it becomes all riddled with holes. Trees damaged by the larvae of Longhorn Beetles can only be used for firewood.

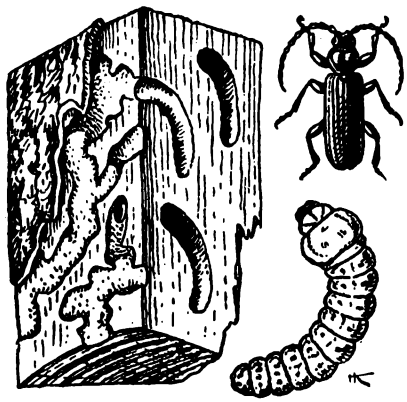

Fig. 42. Spruce Longhorn.
Adult insect, larva and galleries bored in a tree trunk.

Bark Beetles are secondary pests which feed on trees already weakened by primary pests. They bore galleries either in the bark or immediately beneath.

A very widespread pest is the *Eight-toothed Bark Beetle,* a small-

ish, dark-brown insect (Fig. 43), with hollows at the posterior end of its forewings in which to collect the borings—tiny particles which accumulate when the beetle bores a gallery in the solid wood of a tree.

In May, the male bores a *chamber*, and the female—two or three longitudinal *mother-tunnels*, laying eggs in small holes at regular distances along each side. The larvae that hatch out also bore tunnels—*larvae tunnels*, which branch out in different directions terminating in *cradles* where they pupate. In midsummer a new generation of beetles emerges.

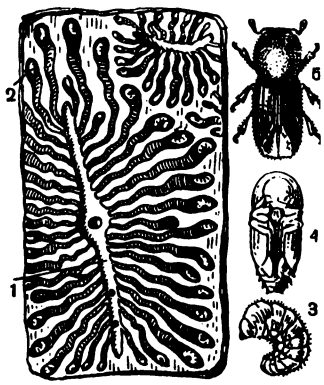

Fig. 43. Eight-toothed Bark Beetle.
1, 2. Galleries. *3.* Larva. *4.* Pupa. *5.* Adult insect.

If Bark Beetles are allowed to reproduce unhampered, they soon destroy the tissues which convey organic substances to the roots, and the host trees die.

Since these secondary pests prefer to settle under the bark, toxic chemicals are ineffective.

Instead, it is recommended that infested trees be felled and the bark stripped from the logs and stumps. Another control measure is to fell some poorly-grown trees and allow them to dry out. The insects will be attracted to them and when the invasion has taken place, the bark should be torn off. The larvae will then die.

Helpful Animals. The *Ichneumon Fly* is a prominent representative of this group. A big insect carrying an ovipositor (a long, slender tube) at the end of its body (Fig. 44), it is armed with long, flexible and extremely sensitive antennae. Running about a tree, it stops still from time to time, to drill through the bark with the ovipositor until it reaches its victim—the larva of a Longhorn Beetle hidden underneath.

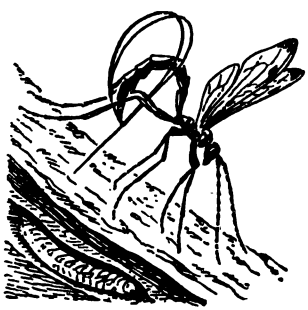

Fig. 44. Ichneumon Fly.
Depositing its ovum into the larva of a Longhorn Beetle protected by the bark.

The Ichneumon Fly inserts only one egg into the larva. When the egg hatches the fly's larva begins to feed on the body of the host, and gradually eats all of it, alive.

Other insects that feed on pests include the *Red Ants*. One colony of Red

Ants is capable of devouring up to 8 million harmful insects in one summer

Forest guardians include some insect-eating birds (see § 60). The *cuckoo* and *oriole* are especially active and useful. They annihilate the hairy caterpillars of the silkworm moths, which other birds neglect. Therefore, these birds should be encouraged to stay in the forests and protected.

§ 20. FIELD PESTS

(Text for Reading)

Migratory Locust. In pre-revolutionary times, the devastation caused by swarms of *Migratory Locusts* (Fig. 45) was dreaded by farmers in the south of our country. The locusts would suddenly appear in immense swarms forming black clouds that blotted out the sun. Settling on the fields they devoured all the vegetation before them and people were often forced to abandon their farms. The farmers were ignorant; there was no one to tell them about the life-cycle of the pest. Helpless in the face of the catastrophe, they regarded it as a divine punishment for their sins.

The locust is similar in general appearance to the larger grasshopper, but has shorter horns. Of the three pairs of jointed limbs, the hind legs are the most developed. By contracting the muscles of the hind legs the insect can leap a considerable distance.

The locust has hardened, elongated forewings with the hindwings folded fanwise beneath them. Adult locusts possess remarkable flying powers.

Reproduction takes place in the reed beds along southern rivers and lakes, which provide a very suitable environment. In the latter half of summer the female digs a hole in the ground with the posterior part of her abdomen, and deposits her eggs. The remainder of the hole is filled with a mucous substance, which, with particles of soil, hardens into a protective covering, an *egg-sac*. The eggs inside (about 50) are reliably shielded against excessive moisture or dryness. They lie there until the following

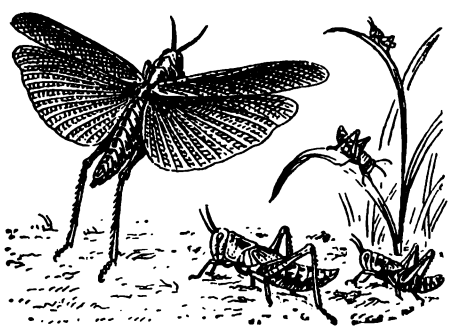

Fig. 45. Migratory Locust and nymphs.

spring, often being soaked by the spring rains and floods. This does them no harm. As soon as the floods subside, the eggs hatch out. The young nymphs greatly resemble the adult insects except that they have no wings and are smaller.

The nymphs, which are wingless, are known as "*hoppers*". To satisfy their voracious appetites they travel from their breeding grounds, the floodlands, to feed in nearby fields. They cast their skins (moult) several times, and grow very rapidly. After a series of changes, the winged stage is reached, and the young locusts develop into adult insects.

As you see, the locust omits the pupal stage. Its metamorphosis is therefore *incomplete.*

Before the Great October Socialist Revolution control measures in Russia were most inadequate. Deep trenches with sheer walls were considered the most effective method. The "hoppers" were driven into the ditches to starve. The work required much manual effort but yielded poor results.

Under Soviet power agricultural aviation has been developed and a chemical industry set up. The USSR took the initiative in using planes for distributing poisonous baits and dusting or spraying locust breeding-grounds with insecticides. After several years of intensive effort the locust has been eliminated and its devastating raids stopped.

The history of locust control is very instructive. When the pest was accepted humbly as a divine punishment and practically nothing was done to wipe it out, locusts multiplied enormously and thousands of farmers were impoverished. As soon as the anti-locust drive was placed on a scientific footing (after the October Revolution), the locust problem ceased to exist.

The almost total extermination of this insect pest in the Soviet Union has proved the value of using scientific techniques to assist agriculture, and the harm done by blind reliance on the non-existent God.

The Soviet Union is at present rendering extensive assistance in organising locust control in Iran, Afghanistan and other neighbouring countries.

Questions: 1. What is the life-cycle of the Migratory Locust? 2. What is a locust egg-sac? 3. Why is the locust described as a pest, and what are the control measures employed against it in the USSR?

Sen Stink Bug (Eurygaster Integriceps). This insect (Fig. 46) which attacks cereals—wheat, rye, and barley—ranks among the most destructive pests.

It causes great damage to immature grain kernels by piercing them with its proboscis, sucking the juice and introducing a poisonous fluid.

As a result, the grain shrivels and becomes lightweight, and a low yield of poor quality is obtained. Flour made from this grain tastes bitter and is low in nutrition.

When the ears of grain are being formed, the females lay their eggs in tiny clusters on the lower surface of the leaves. The young nymphs which hatch out look very much like their parents, but are considerably smaller and have no wings. After shedding their skins several times they develop into mature Sen Stink Bugs. They omit the pupal stage.

If the nymph sucks the juice from grain at the milky stage, it will become an adult insect and lay eggs the next year. If, for some reason, its development is retarded and the nymph feeds on hardened grain, no reproduction is registered. Consequently, one of the methods of control is to sow early-ripening varieties of grain. Early harvesting (at the beginning of the wax stage) is another.

Aircraft of course are playing an increasing part in fighting the pest on the extensive areas occupied by collective and state farms. They either spread DDT or spray chemicals that injure the cuticle of the Sen Stink Bug. This method of dealing with harmful insects is the cheapest.

Cutworm (Euxoa Segetum). This agricultural pest also does much damage. It is the caterpillar of the grey night-flying *Owlet Moth*, which flies as noiselessly as the owl (hence its name).

The eggs are laid on weeds in early summer.

The caterpillars (Cutworms) feed on the weeds first, and then migrate to the fields of young winter crops.

They are ashy-grey in colour (to match the earth) and have nocturnal habits: burying themselves during the day, they crawl to the surface at night and bite through the stems of plants at or near ground level. The damage done by the Cutworm is not easily noticed until autumn when bare patches in the fields become apparent.

In the south the Cutworm destroys sugar-beet, and other crops.

Pupation takes place in the earth in spring.

Large-scale invasions of this pest necessitate urgent measures. One of the most effective is the destruction

Fig. 46. Sen Stink Bug attacking a wheat kernel.

of the host weeds which serve as food until the shoots of the winter crops appear.

Wireworm. This is the grub (larva) of the *Click Beetle*. As the Click Beetles have short legs it is not easy for them to get on their feet again if they happen to fall on their backs. They overcome the difficulty in an interesting way. Bending the body until it rests upon the head and tip of the tail, they then straighten out so suddenly that they strike the ground and spring upwards, turning over at the same time. In doing so they make the sound from which they get their name.

The body of the Wireworm is hard. The grubs, which invade the fields in swarms, damage the roots of cereals and potatoes, and are among the worst enemies of crops. They can be got rid of by introducing a mixture of hexachloran and phosphates, or other insecticides into the soil.

Potato Beetle. A serious potato pest, known also as the *Colorado Beetle*, looks something like the popular Ladybird, but instead of seven black dotted markings on a red body its forewings have alternate stripes of black and yellow (five on each side), which are almost parallel.

The insect was originally a native of America (like the potatoes on which it feeds), reaching Western Europe half a century ago with a consignment of goods. It spread at an alarming rate and caused enormous damage. Recently it was found in the USSR.

The Colorado Beetle spends the winter buried in the earth. In spring it multiplies and spreads over the fields devouring potato leaves. The females deposit masses of elongated orange-yellow eggs on the leaves. The grubs which hatch out are reddish insects, with small black spots. Multiplying rapidly, they strip potato plants bare and poor harvests result.

The voracious grubs grow fast. When grown, they leave the plants, burrow into the soil, and pupate. When the pupation period is over, a new generation of insects crawls out.

If the weather is favourable the Colorade Beetle can produce two generations in one summer.

The remarkable power of reproduction, as well as the amazing

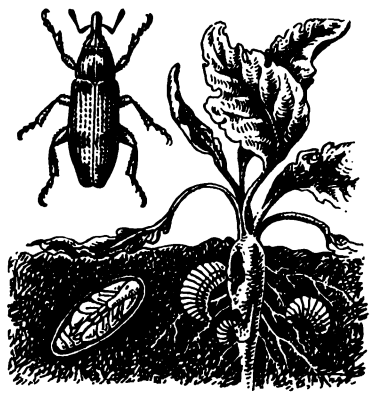

Fig. 47. Beet Pest.
Different stages of development, and the harm the insect does.

Fig. 48. A trench for trapping Beet Pests.

capacity to withstand unfavourable conditions, make this insect extremely harmful. Fortunately, it is not widespread in the USSR, being found only along the western border.

Because the Colorado Beetle is such a serious pest, anyone finding any of these insects must immediately report to the local collective farm management, the rural Soviet, the local agronomist, or a school-teacher.

The insects themselves must be thrown into a vessel containing kerosene or a strong solution of salt, and kept there until the arrival of the plant protection authorities.

All the potato plants suspected of having been attacked by Colorado Beetles should immediately be marked for quick identification. It is forbidden to take live beetles away from the field: they may either escape or be lost, which would mean their further distribution.

Beet Pest. This small insect (Fig. 47) causes great damage to sugar-beet. Feeding first on weeds it later invades nearby sugar-beet plantations. It devours mostly leaves but may also eat through the stalks of young seedlings, causing their death.

The white, legless grubs do great damage to the taproot of beet plants. A heavy infestation reduces the number of healthy plants so drastically that a second sowing becomes necessary.

An effective means of control is to dig trenches with sheer walls (Fig. 48). The beetles fall into them, cannot crawl out, and can easily be killed.

It is also advisable to dust the sugar-beet seedlings with DDT or hexachloran, and also to destroy all weeds.

Questions: 1. What damage does the Sen Stink Bug do? What control measures are used against it? 2. How do Cutworms harm crops? What should be done to get rid of them? 3. What is a Wireworm and how can it be controlled? 4. What must you do if you see a Colorado Beetle? 5. What damage does the Beet Pest do? What are the most effective methods of control? 6. Which of the field pests have complete metamorphosis? Which incomplete?

§ 21. VEGETABLE GARDEN PESTS

(Text for Reading)

Cabbage White. The *Cabbage White*, or the *Cabbage Butterfly* (Fig. 49), is among the most common of butterflies. It is seen hovering over flowering plants in summer. As its name implies, it is white, but has black spots on the upper side of its wings. It is easily distinguishable from afar and escapes falling prey to insectivorous birds due to its uneven flight. It is not at all easy to catch even with a net. When it alights on a plant and holds its wings vertically, it blends with the surroundings and becomes hardly noticeable at all.

If you touch the butterfly's wings you find that a certain amount of silvery white dust rubs off and adheres to your fingers. The dust is composed of minute chitin scales which are arranged on the butterfly's wings in the same manner as larger ones are arranged on the body of a fish. This explains why butterflies have been classified as *Lepidoptera*, i.e., "*scaly wings*". The colour of the wings depends on the pigment inside the scales.

The butterfly flies from flower to flower, seeking the brightest and most fragrant of them, from which to suck nectar. It is guided during these expeditions by its highly-sensitive organ of smell and very sharp eyes. The eyes are big, compound and well developed, occupying most of its head. The antennae usually end in a small swelling or knob.

The butterfly settles on a selected flower and grips it with its long, but comparatively weak, jointed legs. Then it uncoils its transformed mouth-parts, the long proboscis (Fig. 50), thrusts it into the flower and sucks a drop of nectar. In the warm sunshine it flutters around collecting the sweet juice drop by drop. This way of feeding has gradually lengthened the mouth-parts.

The Cabbage Butterfly, however, is a frequent visitor to a far less desirable environment—your vegetable garden, where it does not hover over

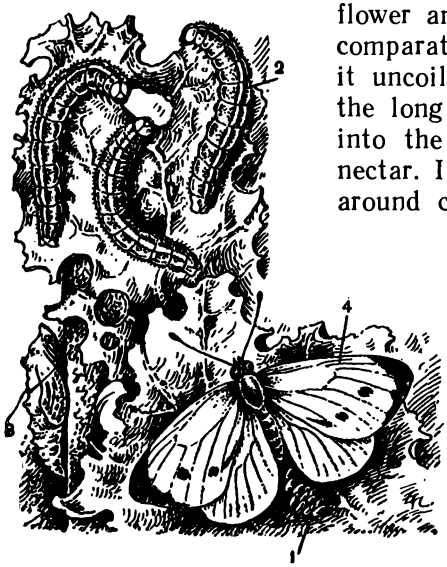

Fig. 49. Cabbage White.
1. Egg-laying. *2*. Caterpillar. *3*. Chrysalis (pupa). *4*. Adult butterfly.

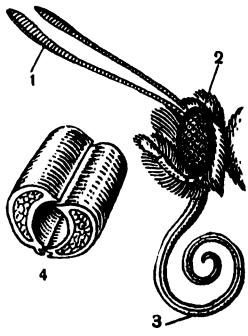

Fig. 50. A butterfly's head.
1. Knobbed antenna. *2.* Compound eye. *3.* Proboscis. *4.* Section of the proboscis (greatly magnified).

pretty flowers but smells the slightly bitter juice of cruciferous vegetables: cabbage, turnip, and kohlrabi. It is on their leaves that the butterfly deposits batches of yellowish eggs.

The caterpillars which hatch out have no proboscis, they chew. They devour cabbage leaves and cause serious damage.

The larvae grow, moult several times, and finally pupate. When they are in their last skin they leave the plants and crawl to a nearby wall or fence, or up a tree to which they attach themselves by very thin threads. There they pupate. They cast their last chitin skin and are transformed into *chrysalises*, which develop into perfect insects (imago).

Cabbage Butterflies have two broods a year: one in spring, out of chrysalises that have lived through the winter, and the second in summer. Butterflies emerge from the autumn chrysalises only after prolonged cooling, which the summer brood does not need.

The first brood develops into butterflies before the planting of young cabbages. Therefore the young insects lay their eggs on various cruciferous weeds. The summer, or second, brood deposits batches of eggs on young cabbage plants. Caterpillars emerge when the leaves have curled and the cabbage heads are ripe.

The butterfly's life-cycle shows that the simplest and most effective method of getting rid of Cabbage Whites is to destroy the eggs. The yellowish batches are easily found on the underside of cabbage leaves. Press your finger once and some 30—40 future pests will be crushed. This must be done at the proper time, however. When the caterpillars have hatched out no finger-pressing will do any good. Each caterpillar will have to be dealt with separately.

It is also useful to keep the garden clean of cruciferous weeds, which serve as food for the spring brood.

Cabbage White Parasites. If you place some eggs of a Cabbage White in a box and keep them under observation, you will find that caterpillars will not hatch from all of them. From some will come very small flies with four transparent, membranous wings. These are *Chalcid Flies*, and include the *Trichogramma* (Fig. 51), a tiny insect which is a parasite on other insects and is specially bred to fight insect-pests.

Do the following experiment.

Find a score of big Cabbage White caterpillars and place them in a box. Provide them with food. You will notice that only some enter

the chrysalis state. The rest have been "ichneumonised", and from them will crawl dozens of little whitish worms, the parasitic larvae of the *Braconid Fly*, which consume the live caterpillars of the Cabbage White leaving nothing but the cuticle.

When the larvae of the Braconid Fly pupate they surround themselves with very fine golden-yellow threads forming small cases that resemble rye grain. At the completion of pupation, the cases are opened and very small insects, with four transparent wings and tiny bodies, crawl out.

Fig. 51. Chalcid Fly (Trichogramma), resting on a butterfly's egg.

An adult Braconid Fly inserts its ovipositor into a Cabbage White caterpillar's body and deposits its eggs. The caterpillar is "ichneumonised".

Another experiment you can do is to place a few Cabbage White chrysalises in a glass jar and cover the top with a piece of gauze. Butterflies will emerge from some of the chrysalises and another kind of *Ichneumon Flies* (*Eurytoma*) from the others.

These experiments, which are quite simple and can be easily carried out, prove that Ichneumon Flies are very useful. Some (Chalcid Flies) spend their larval stage in the eggs of Cabbage Whites, feeding on the contents; others (Braconid Flies) attack caterpillars and eat them alive; the third (Eurytoma) destroy insect pests in the chrysalis stage.

The Ichneumon Fly sits on its victim like a rider on the back of his horse. From this position it thrusts its ovipositor either into an ovum, caterpillar or chrysalis, and deposits minute eggs.

It is strongly recommended that young naturalists breed Ichneumon Flies. To do this collect clusters of eggs of the Cabbage White along with the parts of the leaves on which they were laid; place them on a brick, lying in the middle of a vessel, half filled with water. When the caterpillars hatch out they will crawl down into the water and drown. The Ichneumon Flies will disperse, and attack the eggs of other Cabbage Whites.

Questions: 1. Describe the life-cycle of a Cabbage White. 2. How does it develop? 3. What are the simplest methods of control and when should they be taken? 4. Name the insects which help in the fight against this pest. What do they do?

Flea Beetles (Vegetable Garden Fleas: Turnip Flea, Cabbage-stem Flea, etc.). These small agile insects possess considerable powers of jumping and flight. They live on cruciferous plants boring small

holes in the leaves of kohlrabi, cabbage, turnip and radish—the size of rifle shot. When they do not eat right through the leaves but only to the upper transparent layer, the injury is known as a "*window*" (because the transparent "skin" resembles a pane of glass).

The larvae make yellow tunnels in the leaves, sometimes called *mines.*

Although they make only small holes, windows and mines, fleas cause considerable damage to young plants, retarding their development and sometimes even killing them.

The best and most reliable way to get rid of them is to dust the young plants with DDT and other insecticides. In hothouses fleas can be caught by waving small flags covered with a sticky substance.

Cabbage-root Fly. Everybody knows what a nuisance house flies are, but few have heard of the *Cabbage-root Fly*, the larvae of which—the cabbage maggots—live in the earth and feed on the roots of cruciferous plants. If you dig out the stumps of cabbages in the autumn you may find in many of them a labyrinth of grooves and tunnels made by the maggots.

In appearance, the white legless maggots resemble worms. The under-developed roots of young seedlings are most susceptible to damage from these pests. Plants that have been attacked by maggots wither in hot weather, and there may be considerable losses if proper and timely measures are not taken.

Hilling is the most effective method of control: plants that are hilled form an upper row of roots and are stronger and healthier. It is also possible to apply various toxic chemicals to the roots of seedlings or dip them in a mixture of clay, water and hair from the tails of cows, before planting them out. Subsequently they can be dusted with DDT and hexachloran.

Questions: 1. What harm do Flea-beetles do in the vegetable garden, and what measures should be taken to control them? 2. Why is the Cabbage-root Fly regarded as a serious pest, and what should be done to get rid of it? 3. What kind of metamorphosis do all the insects described in § 21 undergo?

§ 22. GARDEN PESTS

(Text for Reading)

Whitehorn Butterfly (Black-veined White). In autumn, when the fruit-trees have lost their foliage, curled dry leaves hanging on very thin threads may be found on bare branches (Fig. 52), where *Whitehorn Butterflies* have laid their eggs.

If not destroyed, between 20 and 30 small caterpillars will come out the following spring, and begin to devour buds, flowers and leaves of apple-trees, causing considerable damage.

Later they will pupate. In June and July young white butterflies with black veins on their wings will emerge from the chrysalises. Each will immediately excrete several drops of reddish fluid from its intestines. When large numbers of butterflies emerge, the orchards are sprinkled with "red rain", a fluid resembling human blood. In olden times the phenomenon aroused superstitious fear.

The easiest way to deal with this pest is to collect and burn the nests during autumn and winter.

The same measures can be used against another pest, the *Brown-tail Moth*, a snow-white nocturnal insect with a golden-brown abdominal tip. The nests of its hairy caterpillars are commonly found in rolled leaves enmeshed in a light web on the ends of twigs.

Apple-blossom Weevil. When apple blossoms suddenly wither and die before opening, examination will usually reveal the presence of white grubs or chrysalises of the *Apple-blossom Weevil.*

The adult Apple-blossom Weevil is a little brownish bug which has a long proboscis, reddish legs and antennae. The female lays its eggs singly in a hole bored into the immature bud of an apple or pear blossom. The grub devours the stamens and pistil, and then pupates. The petals of the blossom wither and cover the chrysalis like a tent, protecting it from enemies and bad weather.

Buds attacked by the Apple-blossom Weevil produce no blossoms and, consequently, no fruit. Therefore, the weevil is among the worst of orchard pests, considerably reducing apple and pear yields.

The Apple-blossom Weevil exhibits a strong defensive reflex by *shamming death.* Touch a branch and the weevil will drop to the ground like a stone and lie as though dead. This enables an effective method of control: the insects which fall can be collected on canvas sheets spread under the trees to receive them, and then be destroyed.

Codling Moth. It sometimes happens that apples begin to drop prematurely from the trees. If you cut one of them in two you will see a passage and the pinkish caterpillar of a small butterfly called the *Codling Moth.*

The caterpillar feeds on apple seeds. As soon as the damaged apple falls, the caterpillar crawls out, climbs the

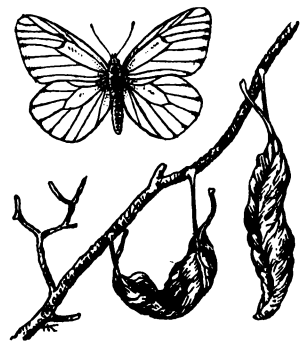

Fig. 52. Whitehorn Butterfly and the winter nests of its caterpillars.

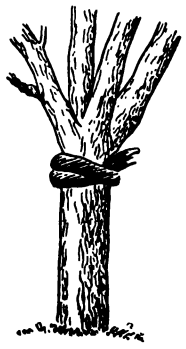

Fig. 53. A sacking catch-band fixed round an apple-tree.

tree and bores into another apple. One caterpillar can spoil a considerable quantity of fruit.

When it is time to pupate the caterpillar sets out in search of a reliable shelter, for instance, in a crack in the bark; it forms a whitish cocoon and stays in it until the following spring. After it emerges from the chrysalis state it is a perfect insect—a butterfly.

The best method of control is to collect fallen fruit and put catch-bands on the trees. The bands are usually made of sacking or straw (Fig. 53). When they are removed and burnt in winter, it will be found that many catterpillars are hibernating in them.

Another method is to use the moth's natural enemies, for instance, the Trichogramma, a parasite which lives on the eggs of many pests. When you notice Codling Moths flying among the trees, hang out a number of small packages containing grain moth eggs infested with the eggs of the Trichogramma. When the young hatch out, they will lay their own, smaller eggs on those of the Codling Moth. The batches of Trichogramma that hatch out will feed on the moth's eggs, thereby protecting fruit-trees.

Questions: 1. Why do we say that the Whitehorn Butterfly is a pest? What is the best control? 2. What harm is done by the Apple-blossom Weevil and what action must be taken to get rid of it? 3. What is the damage done by the Codling Moth? How can it be controlled? 4. What kind of metamorphosis do all the insects described in § 22 live through in their development?

§ 23. PEST CONTROL

Methods. The measures taken to control insect pests fall into several groups: chemical, physical, biological and cultural.

Chemical control is effected by means of various insecticides. How successful these measures are depends on our knowledge of the life and habits of the pests, especially their eating habits.

Leaf-eating pests (locust, butterfly caterpillars, beetles) can be destroyed with "stomach poisons", sprayed or dusted onto the leaves of the plants they attack. The pests take in the insecticides which get into their digestive tracts.

Insects which suck the sap of plants are not affected by stomach poisons but can be destroyed with contact insecticides, for instance, DDT, which is most effective against the Sen Stink Bug.

Tracheal insecticides, introduced as gases or as clouds of smoke which enter the bodies of insects through the tracheae, are effective against those that attack seeds, and are sometimes used in storehouses.

Besides destroying pests, insecticides may injure useful insects, such as Bees, Bumble-bees, Silkworm Moths (Bombyx), Ichneumon Flies, and Ladybirds (which devour aphids). Therefore there are times when they should not be used. The use of DDT and other toxic chemicals, for instance, is banned in the vicinity of beehives and silkworm-breeding farms.

A number of insecticides are harmful to man and should not be used on flowering plants or fruit.

Insecticides are spread by means of different hand, horse-driven, and mechanised dusting and sprinkling machines.

Physical methods of control have been described in the sections dealing with the Cabbage White, Siberian Cedar Moth, Codling Moth, Apple-blossom Weevil, and other pests. They include collecting of eggs, caterpillars and chrysalises by hand, shaking the insects off the infested plants, trapping them with grease bands, etc.

Biological control is a method of destroying pests by using their own natural enemies against them, for instance, the Trichogramma (which may be specially bred for the purpose), and the encouragement of insectivorous birds.

Cultural control consists of effective methods of cultivation, ploughing, applying fertilizer, etc., to ensure that plants are strong and healthy and able to resist the attacks of insect pests.

Sometimes changing the sowing time is effective: damage can be avoided if crops are sown after the insects have appeared, or early so that they are far enough advanced to resist attack.

Pest Control in the USSR. Prior to the Great October Socialist Revolution poor farmers were unable to launch an organized anti-pest drive, and harmful, parasitic insects caused great damage to crops. The peasants knew nothing of insecticides or of dusting and spraying machines; they had no equipment to dig trap-furrows in their fields; and, of course, there was no aviation. The methods of control were extremely primitive.

Soviet power has developed a chemical industry, has built machine-building and aircraft factories. The peasants have united into collective farms. New favourable conditions for fighting insect pests have been provided in the Soviet countryside.

A national programme governs pest control throughout the length and breadth of the country. Special plant protection institutions have been set up. Breeding grounds of pests are located promptly and kept under strict observation. Large-scale manufacture of insecticides has been organised. Aerial spraying and dusting are efficiently carried

out. Improved farming methods and mechanisation on the state and collective farms have also helped greatly. By these measures the distribution and numerical strength of pests have been drastically reduced and the damage to agriculture greatly lessened.

Questions: 1. What insect pests have you seen in your locality? What is being done to get rid of them? 2. What are the methods of control practised in the USSR? 3. What has been achieved in our country in fighting pests?

§ 24. INSECTS WHICH TRANSMIT DISEASE

Mosquitoes (Gnats). Mosquitoes, or their more common variety—the *Northern House Mosquitoes* or *Gnats* (Fig. 54), appear early in spring, as soon as the snow has melted away. They are all females that have survived the winter. They hurry to small, stagnant, warm ponds to deposit floating egg-rafts.

After several sunny spring days swarms of very active larvae appear.

Watch what they do when the earth trembles slightly due to, say, a passing lorry. They dive, as if by command, making zigzag movements on their way to the bottom. In a minute or two, they swim up again, and rest head downwards, tail up.

The larvae live in the water but breathe fresh air. The tip of the abdomen carries a *breathing tube* (a siphon), the opening of which is at the surface when the resting larvae breathe. The body is kept at a certain angle to the water surface, and the head hangs downwards. The larvae feed on decaying vegetable matter and floating microorganisms, which are caught in the mouth.

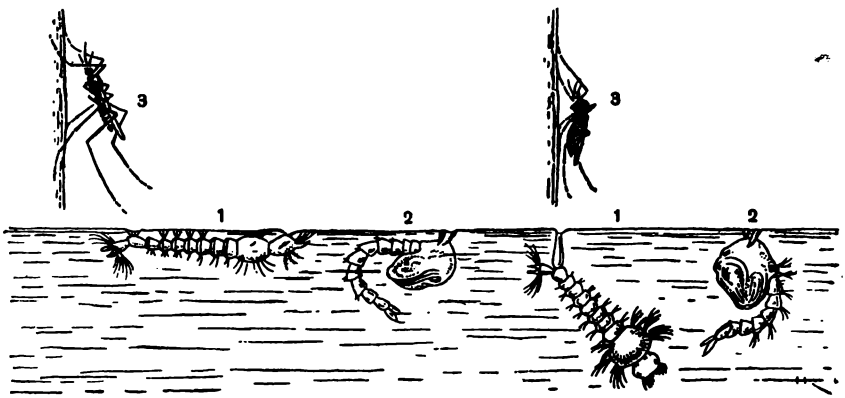

Fig. 54. Mosquitoes. (*Left*) Malaria Mosquito; (*right.*) Northern House Mosquito.
1. Larvae. *2.* Pupae. *3.* Adult species.

The comma-shaped pupa is quite large and very active, and spends its life in the water. It has a pair of breathing trumpets on its chest.

When after pupation the adult insects emerge, the transformation takes place at the surface of the water. The chitin pupal skin splits on the dorsal side, and a mosquito breaks out. Until it dries and flies away it uses the skin as a raft. This is a critical period in the mosquito's life-cycle: the slightest disturbance can lead to death. They do die, in great numbers.

Among the blood-sucking mosquitoes it is only, the females that bite: they need blood to ripen their eggs. They may be regarded as parasites, but not "*endoparasites*" (internal) like, for instance, the worms, because they do not live inside the host; they are "*ecto-parasites*" (external) because they take their food on the host's surface, spending only a short time there (while sucking blood). The males are vegetarian (sucking the sap of plants).

In the warm summer months female mosquitoes are very troublesome, especially in swampy areas, for example, the taiga and tundra.

The *Malaria Mosquito* is easy to distinguish from common gnats (Fig. 54): at rest its body is carried at an angle to the surface on which it stands, with the posterior end elevated. The ordinary, northern house mosquito holds its body parallel to the surface.

Both types lay eggs on the surface of shallow, still water. Only the Malaria Mosquito lays its eggs singly, sometimes in hollow trees holding stagnant water.

The larvae of the Malaria Mosquito do not hold their bodies at an angle to the water surface, like those of the common species, but parallel to it. They have no respiratory siphons and absorb fresh air through a pair of breathing trumpets situated on the posterior end of the body. The pupae of the Malaria Mosquito have larger trumpets than their ordinary counterparts.

Malaria Mosquitoes are dangerous parasites which should be destroyed. Control is quite simple while the larvae are still in the water: oil or kerosene poured on the surface blocks breathing tubes, or trumpets, of the larvae or pupae, suffocating them. (Other measures were described in § 4.)

Protection can be obtained by rubbing a preparation such as "Taiga" cream into the skin or wearing mosquito nets.

House Fly. The House Fly is dangerous because it spreads various infectious diseases as well as the eggs of parasitic worms.

The whitish worm-like fly larvae live and develop in dustbins or manure—this is where the eggs are usually laid (Fig. 55).

Before it pupates, the larva crawls out of the manure or refuse and burrows into the earth. The pupa is protected by a small, brown pupa-

rium, which looks like a tiny barrel and consists of the last larval skin which is never cast.

The period between the egg-laying and the emergence of the adult insect is short: 5—7 generations may be produced within one summer. One female House Fly can produce more than 5,000,000,000,000 flies by autumn if all the eggs can hatch and develop. If several females are allowed to survive the winter in your house or in a cattle-yard, both premises will swarm with flies by the end of the summer. The greater the number of House Flies, the greater the spread of disease, particularly intestinal disorders.

This is because of the feeding habits of flies: they search for food everywhere, flying from lavatories and refuse heaps to foodstuffs (which should never be left exposed). They carry on their legs the bacteria of typhoid fever and other intestinal diseases, as well as the eggs of Ascarid worms. This is why all foodstuffs should be protected from flies with gauze or glass tops, and vegetables and fruit should never be eaten unwashed.

A House Fly may crawl over the sputum of TB patients, and spread this serious disease as well. It can also carry trachoma—after contact with the whitish pus that accumulates at the corners of the eyes of an infected person. Trachoma is another serious disease.

Flies must be exterminated at all stages of their life history. Refuse heaps and lavatories, which are the breeding places of their larvae and pupae, must be sprinkled with chloride of lime or DDT. Adult insects must be cleared out with the help of toxic fluids, glue paper, etc.

Fig. 55. The life-cycle of a House Fly. *1*. Adult species. *2*. Eggs. *3*. Larvae. *4*. Puparium.

Louse. *Lice* are also external parasites on man (Fig. 56).

Head Lice cling to people's hair, cementing their eggs (which are called "nits") on it. *Body Lice* hide in clothes, where they deposit their eggs.

The larvae that hatch out are like adult insects, except that they are smaller. Within a month, one blood-sucking female is capable of producing several hundred young.

Lice are parasites, and as such have developed certain structural peculiarities, which are absent in free-living insects. For their size they have very powerful claws on their legs, with which they cling to hair or clothes. They use their mouth-parts for biting or sucking. They puncture the skin, inject highly toxic saliva, and suck the blood. All lice are wingless.

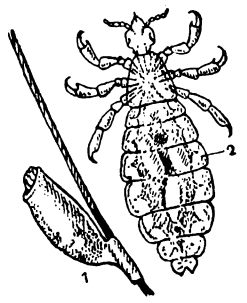

Fig. 56. Louse.
1. A nit clinging to a hair. *2.* An adult insect.

Lice carry pathogenic agents causing typhus (spotted fever), a very serious disease. When scratching lice wounds, people rub in the lice excrements which may contain the microscopically-small bacteria from someone suffering from the disease.

To keep yourself free of lice observe the rules of personal hygiene: take hot showers daily, wash your head frequently, have your hair cut regularly, often change underwear, iron the folds of your clothes.

If you see a louse, take your clothes immediately to a sanitary station where they will be fumigated.

Flea. *Fleas* (Fig. 57), like lice, are well adapted to living as external parasites on human beings. Their mouth-parts are modified to pierce the skin and suck the blood. They are wingless. The third pair of legs is much longer and more powerful than the first two. This is why fleas can hop so far. A flea is not easy to catch because it is small and extremely lively. It is protected by a hard chitin sheath which does not easily yield to pressure.

Eggs are laid in cracks in the floor and the sleeping mats of dogs and cats, or in refuse or garbage. The larvae look like little caterpillars. They are white and legless, and feed on decaying organic matter. Pupation takes place without a change in the environment. In summer metamorphosis is completed within a month.

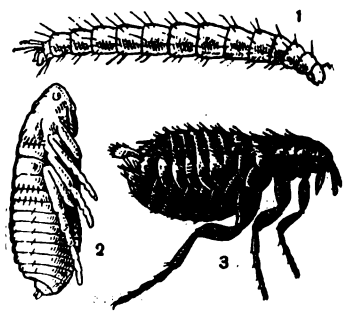

Fig. 57. Flea.
1. Larva. *2.* Pupa. *3.* Adult flea.

In areas infested with rodents (especially susliks and rats) fleas may be the carriers of bubonic plague. In our country, thanks to the achievements of Soviet medicine, plague has been almost completely wiped out. However, the rodents remain. Therefore, to prevent epidemics measures must be taken

against rodents and fleas. DDT is most effective against flees. It is also advisable to keep floors clean.

Epidemic Control. There was a time when people did not know the real causes of infectious diseases. They were full of superstitions and frequently attributed epidemics of plague to witchcraft and sorcery. While many innocent victims ended their lives on fires, infectious diseases raged uncontrolled.

A radical change in the methods of control took place after the discovery of pathogenic agents and carriers. In the Soviet Union the development of health services and the general rising of cultural standards did much to combat disease. Even during the Great Patriotic War there were no outbreaks of typhus, which had been a scurge during all the previous wars, taking an even greater toll of human life than the hostilities themselves.

However, carriers of pathogenic agents must continue being combatted on a national scale.

Questions: 1. Describe the life-cycle of an ordinary mosquito (gnat). 2. What is the difference between a Malaria Mosquito and a gnat? 3. What should be done to get rid of house flies? 4. How do lice and fleas endanger health?

§ 25. SILKWORM MOTHS

Silkworm (Bombyx). The common *Silkworm* is the caterpillar of a large, night-flying moth, and is one of the most useful of insects (Fig. 58). For thousands of years it has been bred in captivity. Because species with poor flying abilities (they were easier to deal with) were chosen for breeding purposes, the moths have gradually lost their power of flight. They are only able to crawl.

Their ability to produce silk threads makes them very valuable to man. Silk consists of a thick solution which comes from two *silk-excreting glands.* The glands are like two long tubes, lying along the body of the worm, with an opening at one cone (the "spinnerett") on the lower lip. On contact with air, the solution they produce hardens quickly into a thin thread of silk.

The worm uses the silk thread to make a cocoon in which to pupate. Before beginning to spin, it attaches itself to a hard surface by means of a thread expelled from its cone. It then proceeds to surround itself with silk thread. There may be as much as 700 or 800 metres of silk thread in a cocoon, or even 1,500 metres and more, under very favourable conditions. The cocoon provides a reliable shelter and protects the chrysalis from adverse conditions.

The Chinese were the first to use silk threads to make fabrics. Several thousand years ago the industrious farmers of China learnt

to feed Silkworms on the leaves of the *mulberry tree*, which grows in the south of the country, and to use the cocoons as raw material for manufacturing silk.

Silkworms have been bred in the Soviet Union for quite some time. In spring, in specially prepared rooms or sheds, the Silkworm eggs (also known as "*graine*") are scattered on sheets of paper spread on tiers of canvas shelves or tables.

When the Silkworms hatch they are fed first on strips of mulberry leaves and eventually on whole leaves. When the tiers are cleaned the worms are transferred from one place to another on leaves or twigs, but never touched by hand.

Fig. 58. Silkworm Moth.
1. Adult insect. *2*. Eggs. *3*. Caterpillar or Silkworm. *4*. Cocoon.

The caterpillars grow fast, and moult several times. Before each mouting they grow inert, their appetite lessens, and they fall into a state which greatly resembles sleep.

When the larvae are about a month old, bunches of dry leafless twigs are placed on the shelves. The Silkworms climb onto them and begin to spin their cocoons.

When the spinning is completed the cocoons are collected and sent to the silk-weaving mills. In the mills the pupae are killed by steam. The silk is wound off the cocoons, the threads twisted together into yarn, and woven into silk fabrics. The dead pupae are used as food on fur farms.

In the Soviet Union silkworm eggs are produced at silkworm nurseries, where pupae are not killed but allowed to develop into moths, which lay great numbers of eggs. The eggs are supplied to hatcheries.

Chinese Oak Silkworm. This silkworm, which feeds on oak leaves and produces the silk known as tussore, is also bred in captivity. It does well in the central zone of Russia, where it eats birch and other leaves. There is every prospect that its cultivation will spread even further north.

Questions: 1. Describe the life-cycle of a Silkworm moth. 2. On what are Silkworms fed to make them produce cocoons? 3. What is the economic importance of the Chinese Oak Silkworm?

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§ 26. HONEY-BEE

Colonies. Bees live in beehives, in *colonies*, where they have a rigid caste system. There is one *queen* (Fig. 59), which is bigger than the other members of the colony. Unlike other bees, she does not fly from flower to flower in search of nectar or pollen, but stays in the hive moving around the wax combs, laying eggs very liberally into the six-sided cells. She is the only female that is allowed to lay fertile eggs.

The bulk of the colony (tens of thousands) is made up of *workers*, which are also females but do not lay eggs because their reproductive organs are insufficiently developed (they are sterile). They do all the work in the beehive. They build combs, collect food, take care of the young grubs, and guard the hive against robber bees and other enemies.

Then there are the *drones* (from several scores to several hundreds), which are all males and the largest bees in the colony (except the queen). Drones are distinguished by large eyes which converge on the back of their heads. Their only duty is to fertilize the queen. They do not bring food, take care of the young grubs, or clean out the cells, etc.

Worker-bees. Worker-bees are capable of long flights sometimes going 1 km. or more from the hive in search of food. Like the drones and the queen, they have two pairs of membranous wings.

Their mouth-parts have been modified to serve purposes other than taking food. The upper jaws (mandibles), which are shaped like little flattened spoons, are used to grind pollen and build cells. The lower mandibles together with the lower lip (labium) form a proboscis.

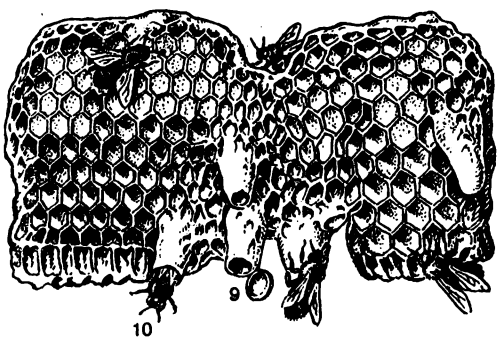
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Fig. 59. Bees.
1. Worker-bee. *2*. Queen. *3*. Drone. *4*. Worker-bee (ventral view showing the wax pockets). *5—7*. Larvae. *8*. Pupa. *9*. Queen cell. *10*. The emergence of the queen.

The bee flies from flower to flower sucking aromatic nectar. The nectar is taken into its mouth and moves to the *honey-stomach*, which is a storage crop. In the honey-stomach the nectar is mixed with saliva and changed into honey. When the bees return to the hive after their expeditions they place the honey in the open comb cells and allow it to undergo evaporation to remove a large portion of water. When this is completed, the honey is used as a food supply for the whole colony.

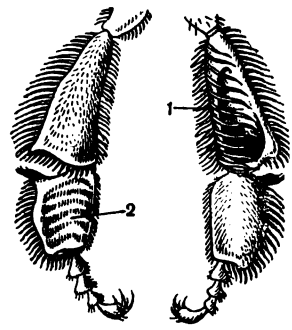


Fig. 60. Hind legs of a bee. *1*. Pollen basket. *2*. Pollen brush.

Honey is also used by man. It contains a number of vitamins, is helpful to people suffering from emaciation, improves blood composition, and is very effective in the treatment of colds.

When a worker honey-bee returns to its hive after finding a rich source of nectar or pollen, it performs a kind of round dance over the combs of the hive to attract the attention of the other bees. When it sets out again the other bees follow it to the source of food.

Worker-bees also collect pollen, which they gather from flowers with their *mandibles* and moisten with saliva. Another way of collecting it is by means of the *pollen brushes* which are on the legs and are formed by projections on the leg joints, lined with short bristles (Fig. 60). The brushes pass the pollen, which adheres to the body of the bee, towards the hind legs where it is packed in two depressions known as the *pollen baskets*. The pollen collected in this way rolls into balls (*"breech"*). When the bee returns to the hive it pushes the balls out of the pollen baskets into the cells of the wax combs.

The stay-at-home bees mix the pollen with honey, store it in special combs, pack it, and seal the filled cells with a thin layer of wax. This is *bee-bread*, the community's stock of food containing proteins, which are essential for their diet.

On the underside of its abdomen the bee has smooth hairless spots, known as *wax pockets*. This is where wax is exuded from the skin. As soon as a small scale of wax is formed, it is removed by the legs. Using its upper jaws (mandibles) the bee moulds the wax into cells. This work is usually carried out by a great number of bees.

At the end of their abdomens the workers and the queen have *stings*, which can be thrust out and withdrawn. The sting consists of three hard blades with barbed chitinous edges. The bee bends its body and drives in the sting, at the same time forcing a burning fluid into the flesh of the victim from a poison bag. The barbed

blades become firmly fixed in the thick skin of the mammal or human being. When the bee attempts to withdraw the sting it is torn out of its abdomen which causes the bee's death. In the chitin-covered body of the Arthropods the sting does not stay but can be easily withdrawn.

Though a bee sting can be very painful, the poison contains medicinal properties and is used extensively in the treatment of rheumatism and other diseases.

Life-cycle. If you examine the wax combs you will see that the cells are of different sizes. The worker cells are the smallest, the drone cells are larger than those of the workers but smaller than the *queen cells*. The queen lays two kinds of eggs: out of one kind (unfertilized) hatch drones; out of the other (fertilized)—either queens or workers, according to the kind of cell in which the egg is laid and the food fed to the grub. The combs which are not occupied by eggs and larvae serve as food stores (for honey and bee-bread).

The eggs hatch into grubs (larvae)—white, wormlike, and legless. For the first few days all, without exception, are fed on a highly nutritious food called royal jelly, which is secreted from special glands by young worker-bees and is regurgitated through their mouths. Later the grubs, in the small and medium-sized cells, are fed only on honey and bee-bread, whereas the queen larva is given royal jelly. This grub grows faster, becomes much bigger than the other larvae, and is the first to pupate.

Distribution of Work. The duties of the bees within the colony depend on their age. A young worker-bee cleans out the cells. Then it is promoted to the position of a nurse, because it is better able to excrete the royal jelly than the older workers. Still later, when its wax-secreting glands mature, it is allowed to build combs. At this stage it also handles the honey, pollen, etc., delivered to the hive by the foragers, and clears away the scraps of refuse. Finally, it joins the food-gathering bees, and goes in search of nectar and pollen.

The building of combs is the most difficult part of the community's life. With their legs, bees remove little pieces of wax from the wax pockets, chew them with their jaws, make a foundation out of the mass that is formed, and cover it with one row of six-sided cells on both sides (back to back). This work is done by large groups of bees and consists of a chain of strictly alternating processes, called reflex actions.

Nursing the young grubs, feeding them with royal jelly, collecting nectar and pollen, keeping the beehive in order—are also parts of a chain of reflex actions, alternating in a definite order.

Such chains of reflex actions which are interconnected and take place in a strict succession are called *instincts*.

Are Instincts Automatic? The complex, seemingly purposeful and clever instincts of bees have given rise to the supposition that these insects can think. A convincing answer was provided by the experiments on wild *Black Mason Bees*, which were carried out in the middle of the last century by the French naturalist F a b r e.

Black Mason Bees are large insects with dark-violet membranous wings and black velvety bodies. They do not make their cells in hives but on large pebbles, where they can get plenty of sunshine. The building material is clay and lime powder. The mixture, moistened with saliva, dries fast and forms very solid cell walls in which the larvae live.

Fabre found two pebbles, each carrying Black Mason Bees' cells, with the grubs in them due to emerge soon. He took two small sheets of grey paper and fixed one onto the cement walls of the cells on one of the pebbles. The other, curled into a cap, was placed around the second nest. In both cases the young bees had to cut their way out of the cells through a cement wall and a sheet of grey paper. But in the second there was a space between the cells and the paper.

Observations proved that the young bees emerging from the first nest did not mind the presence of a double wall. However, in the second case, having easily cut through the hard cement barrier they did not even attempt to break through the second, which was thin. And they all died, "lacking the slightest trace of intelligence," Fabre wrote.

This and many other experiments make it possible to assert that insects only seem to possess intellect or the power to reason. It is wrong to ascribe human reason to animals.

Questions: 1. What castes are there in a bee colony? 2. Describe the life-cycle of a bee. 3. What peculiarities in the bees' structure are associated with plant pollination and food provisioning? 4. Why is it wrong to say that a man has been bitten by a bee? 5. How do bees' duties vary depend on their age? 6. Can we say, because of the way they behave, that bees have the power to reason?

§ 27. BEE-KEEPING

Hives. The natural home of honey-bees is in a hollow tree, where they are reliably protected from unfavourable weather and the quadruped honey-seekers, the brown bears.

In ancient times people searched for trees inhabited by honey-bees, felled them and robbed the hives without a thought of what would happen to the bees. This predatory method of procurement led to the destruction of many trees and diminished the number of bee colonies. The Slavs learnt early to make hollows in trees to at-

tract colonies of wild bees. The first man-made hives, called *bort*, could not be dismantled. They were either installed in the trees or suspended from branches. They were made from hollowed pieces of tree trunks, supplied with a bottom, covered by a lid, and having a small entrance. They were most uncomfortable, clumsy, and difficult to use.

In 1814 the Ukrainian bee-keeper Pyotr I. Prokopovich built a *leaf hive* (Fig. 61). It was a big box in which were placed a number of comb-carrying frames. The floor and roof could be removed. The model answered all the biological requirements of the bees. In it they lived as they did in hollow trees, and they produced much honey. It could be easily taken apart, examined and cleaned.

The invention, and subsequent improvements, made a real revolution in bee-keeping, making of it a very profitable enterprise.

Taking Care of the Stock. The routine work of the bee-keeper (apiarist) consists mainly in examining the stock and the frames, cleaning the hives, replacing worn-out combs, etc.

One should wear very clean clothes when visiting an apiary, because bees become very excited when they smell sweat. The two basic requirements are a *protective veil*, which is fastened on the bee-keeper's head, and a *smoker*. By pressing the bellows of the smoker, a jet of smoke can be puffed into the hive. The bees get frightened and start frantically withdrawing the honey from the combs. The occupation diverts their attention from the presence of the intruder. Moreover, their bellies full of honey, they are no longer able to bend them in order to sting.

Swarms. In summer, when honey-bearing plants are in full blossom, the numerical strength of bees in the hive grows and the hive becomes overcrowded. This causes the bees to swarm, which means that part of the colony leaves to find a new home.

Some time before swarming, worker-bees build a new queen cell, which is different in shape from the ordinary kind and looks like an *acorn cup*. The larva which hatches from the fertile egg deposited in this cell is treated quite differently by the workers: it is a "baby princess".

When swarming time comes some of the workers leave their tasks. A wave of excitement runs through their ranks.

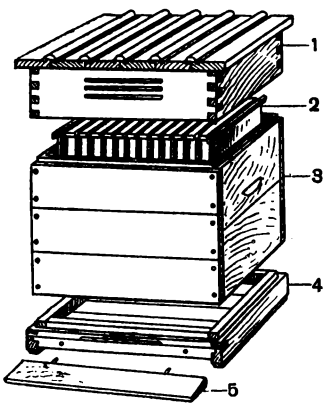


Fig. 61. A leaf hive.
1. Roof. *2*. Frames. *3*. Box. *4*. Floor. *5*. Alighting board.

They fill their bags with as much food as they can hold. When the young princess starts trying to break her way out of the cell, the old queen departs with her suite. She cannot fly far, so she settles on a branch of a nearby tree. The bees follow her and gather around quickly in a cluster. This is a swarm (Fig. 62). If a bee-keeper is near, he will collect the bees and transfer them to an empty hive. The bees will take possession of it, and he will have a new colony.

Fig. 62. A swarm of bees on a tree branch.

Nowadays bee-keepers do not wait for the bees to swarm on their own initiative. They resort to *artificial swarming*. Several methods have been devised which make a bee colony split. The simplest is the following.

On a warm, sunny day, the bee-keeper installs a new, vacant hive beside the one he wants to divide. Then he removes some of the combs with the queen and worker-bees from the old hive and transfers them to the new, empty hive, thus forming a second stock of bees. In performing these operations he takes care to leave the frame with the "princess cell" behind. Then he moves the two hives half a metre to the left and right from the place where the old hive was standing.

The food-gathering bees divide between both hives in almost equal portions, when they return from their foraging expeditions. The old queen settles in the new hive, whereas in the old one the young princess breaks out of the "royal cell". She mates with a drone and returns to lay eggs, thus becoming the mother of the colony. As a result, two families of bees have been formed, instead of one.

Pollination. Visiting one flower after another, bees ensure cross-pollination. This is even more important than producing honey or wax. Some state and collective farms in the Soviet Union have established apiaries to increase yields. Sometimes (for the same purpose) beehives are taken to the fields when honey-bearing plants begin to bloom (for instance, buckwheat).

Bees can be artificially attracted to plants which it is necessary to pollinate. For this purpose a small vessel containing sugar syrup

is placed on the frames of the hive. An infusion of flowers from the plants which are to be pollinated is added to the syrup. After drinking some of the syrup, the bees will begin to search for flowers giving off the same fragrance. This is a useful way of increasing the effectiveness of pollination and consequently raising plant yields. At the same time greater stores of honey are accumulated in the hives.

Wintering. When the weather grows cool, the worker-bees drive the useless drones out. They themselves remain in the hive with the queen, and consume the food stored during the summer.

The hives are moved indoors and the room temperature is not allowed to get too high. The bee-keeper makes sure that the bees move less and consume little food. He protects them from rats and mice, and takes care that none of the hives run out of food.

Nowadays bees are made to work for man's benefit even in winter: if you place a hive in a hothouse, the bees behave as they would in summer. They fly among the plants and pollinate them (for instance, cucumbers).

Questions: 1. What is a beehive like? 2. What do the duties of a bee-keeper consist of? 3. How can we use bees to increase the fertility of plants? 4. What do bees do in winter?

§ 28. FRESH-WATER CRAYFISH

Crayfish Fishing. The *Fresh-water Crayfish* (Fig. 63) is found throughout the Soviet Union. It lives on the beds of rivers, lakes and fresh-water ponds, where it crawls about on its long, jointed legs.

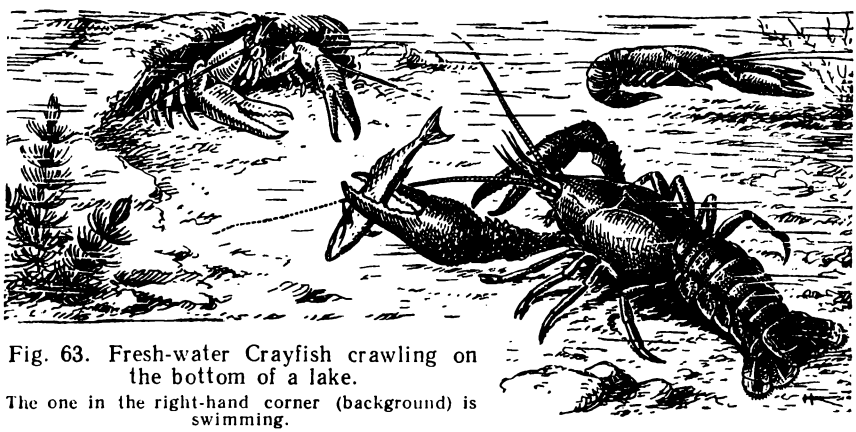


Fig. 63. Fresh-water Crayfish crawling on the bottom of a lake.
The one in the right-hand corner (background) is swimming.

By day it hides in the crevices of rocks or under stumps near steep banks, coming out at dusk or during the night, when it appears to be more active.

It swims swiftly backwards, by powerful strokes of its tail.

The crayfish feeds on small animals and the decaying corpses of bigger ones, to which it is attracted by their odour.

The crayfish is caught in "pots" or "creels" (Fig. 64), baited with pieces of stale, malodorous meat. The pot is made of stout cord netting. It is set on the bottom and removed after some time, and the catch is transferred into a basket lined with moss or stinging nettles.

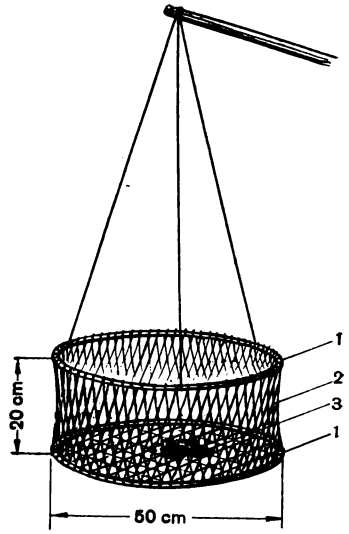


Fig. 64. A "pot".
1. The two holding wire rings. *2*. The netting. *3*. The bait.

Structure. Unlike the insects, the body of the crayfish is divided into only two sections: the cephalothorax and the abdomen.

The *cephalothorax* is covered with a carapace and carries two pairs of *antennae* (long and short), compound *eyes*, *mouth-parts*, and ten segmented *legs* (Fig. 65). The first pair of walking legs, which carries huge *claws* (*"nippers"*), is very big.

Unlike the cephalothorax, the abdomen consists of segments. It is flexibly connected with the cephalothorax and can be bent underneath. Each segment of the abdomen carries a pair of short dovetailed appendages, the *maxillipeds*. The abdomen ends with flattened, solid appendages, the *uropods*. The last uropod carries the anus.

Body Cover. The body of the crayfish is protected by a *chitinous exoskeleton*, which is thicker and harder than that of the Maybeetle. It contains considerable quantities of lime and is an excellent armour. The muscles are attached to the inside of the exoskeleton, controlling the action of the animal's legs, antennae and other organs.

The chitinous cover is rigid, it cannot stretch. Therefore, the process of growth is linked with periodic moulting.

When alive, the crayfish is commonly the colour of its environment. The colour may be varied a good deal by the action of the pigment chromatophores found in the chitinous cover: red, dark blue, green or brown. When the animal is thrown into boiling water all

these pigments are destroyed, except the red one. That is why boiled crayfish is always red.

The muscles under the exoskeleton are covered by a thin epithelium, the *hypodermis*, which secretes a new layer of chitin each time the animal moults.

Orientation. Guided by well-developed senses the animal moves easily about in its natural environment. The *eyes* are *compound* and located on movable stalks. This makes up partly for the immobility of the head which forms one whole with the thorax. The crayfish can move its eyes sideways without having to turn its body.

The long antennae serve as *feelers*; the short ones act as *organs of smell*. The sense of smell is very keen. The crayfish scents dead animal matter from afar.

Nutrition. The crayfish catches its food with the nippers of its first pair of walking legs, and the 6 pairs of hard plates—the *jaws* and the *maxillipeds* are used to hold and crush it.

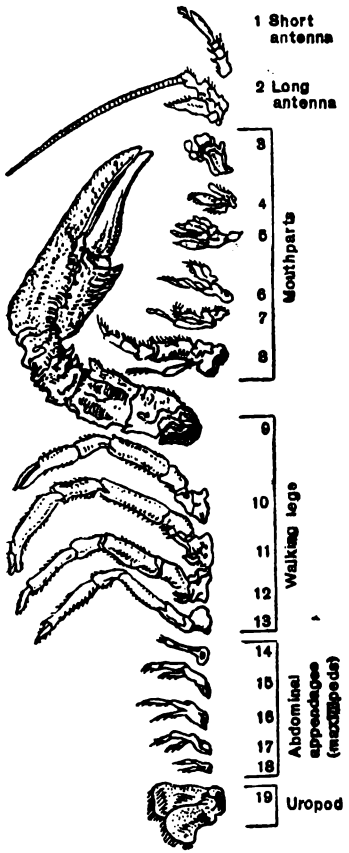


Fig. 65. Crayfish showing the appendages

In the *gastric mill* the food is further ground by tooth-like bodies ("ossicles") and is later digested by the *liver* juice. Digestion continues in the *upper end of the intestine*, where the food is absorbed.

Breathing System. Living in running water, the crayfish breathes with *gills*, delicate, feather-like frills situated in special cavities inside the lateral walls of the protective carapace.

Water carrying dissolved oxygen, penetrates through special openings, which lie at the base of the cephalothorax, enters the gill cavities, and moves over the gills. If you drop a small amount of Indian ink near the cephalothorax of a crayfish, you will notice the ink being drawn into the gill cavities and pushed out from the anterior end. The current is caused by swift movements of the maxillipeds.

Circulatory System. The circulatory system of the crayfish consists of a heart and blood vessels. The *heart*,

which lies on the dorsal side of the body, is shaped like a small bag. *Vessels* lead away from it conveying the animal's blood to all parts of the body. This type of circulatory system is known as an open blood system, and is the same as that of the arthropods.

Excretion. Wastes are withdrawn from the body by the *green glands*, thin-walled greenish bladders found in the front part of the cephalothorax.

Reproduction. The sexes are separate. The female *ovaries* produce immense quantities of *eggs*, often called "*roes*". When matured, they are passed out of the body along short *oviducts*.

Fertile eggs stick to the abdominal appendages ("swimmerets") of the mother. When they hatch the young also cling to them until big enough to tend for themselves.

Questions: 1. What does the Fresh-water Crayfish look like? 2. What is its body covered with? 3. How does it move? 4. How does it take food and breathe? 5. Has it the ability to orientate itself?

§ 29. DAPHNIA AND CYCLOP

Daphnia. The *Daphnia*, or *Water-flea*, is a minute crustacean. Its tiny semi-transparent body, the size of a pin-head (Fig. 66), can easily be kept afloat. The Water-flea uses its swimming organs, a pair of well-developed, forked *antennae*, to move about in a somewhat jerky manner (hence the common name "water-flea"). The legs are underdeveloped and weak.

The Daphnia feeds on very tiny organic particles and micro-organisms floating in the water. Enormous quantities of Daphnia are in turn consumed by fish fry.

Soviet experts have evolved special methods of breeding Daphnia to feed fish at collective and state farms.

Fresh manure and chopped hay are thrown into a hole dug on a sunny bank of a pond where carp fry are bred. The hole is then filled with pond water containing Daphnia. When the temperature rises to 18—20°C, para-

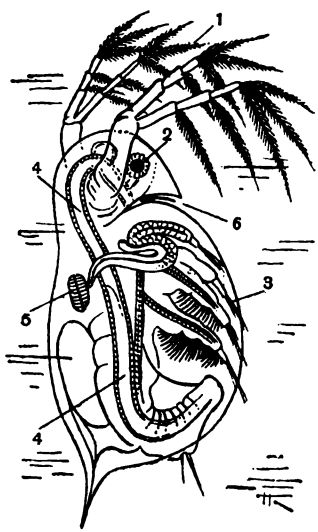


Fig. 66. Daphnia.
1 and *6*. Antennae. *2*. Eye. *3*. Underdeveloped legs. *4*. Gut. *5*. Heart.

mecia and other infusoria multiply very rapidly, providing food for the Daphnia which proceed to grow and reproduce at a great rate.

Cyclop. Fish eat not only Daphnia but also *Cyclops*, one-eyed crustaceans, even smaller than Water-fleas. As distinct from the Water-fleas, they have simple long antennae.

Questions: 1. What is the structural difference between the Daphnia and Fresh-water Crayfish? 2. What is the economic importance of the crustaceans?

§ 30. GARDEN SPIDER

External Anatomy and Behaviour. When walking through a wood or your garden in late summer, you may brush past many spiders' cobwebs. Catch a fly and throw it into one of them. At once a big spider with a light-coloured cross on its back (Fig. 67) will leap upon the fly from its place of concealment (usually a rolled-up leaf). If the *Garden Spider* is big, it is a female; if small—a male.

It is fascinating to watch the spider deal with its prey. It first entangles it in a thin web and then pierces the body with its *upper jaws*. Each jaw carries a sharp flexible fang which can be drawn in and out, like the blade of a pocket knife.

Through a small opening at the tip of the fang, poison is injected into the fly's body. The fly becomes paralysed and dies.

As soon as the fly is dead, the spider quietly returns to its shelter. If, however, you catch another insect and throw it into the web, out it will run again.

Catch the spider, place it in a test tube, and examine its body carefully.

The body consists of a cephalothorax and an abdomen. (Remember the crayfish.) Four pairs of segmented *legs* and two pairs of *jaws* are attached to the underside of the *cephalothorax*. One of the jaws has already been mentioned. The second pair is like two short legs on the sides of which are feelers. These are called *pedipalps* and act as organs of *touch*. Grouped along the front edge of the cephalothorax are four pairs of simple *eyes*.

The *abdomen*, the most conspicuous part of the spider's body, has no external segmentation. On its posterior end is a battery of little projections, the *teat-like spinnerets*. The spinnerets secrete a fluid which is produced in the *glands* and which hardens on exposure to air to become delicate *thread* from which cobwebs and the cocoons that enclose the spider's eggs are constructed.

Some spiders use the web as a means of moving to a new home: a newly-hatched spider spins out a long thread, which floats in the

wind until it becomes entangled in an adjacent tree. This provides a line along which to walk.

Considerable distances can be covered in this way helping spiders to spread fast throughout a locality.

Cobwebs. The *instinct* enabling the spider to spin cobwebs is its most remarkable feature. The threads it spins are very fine, but it can put them together with the help of the *comb-like little claws* on its hind legs to form a thick, non-adhesive line. To begin with, the spider builds a manysided framework, which it secures to solid objects. Then it spins a long line to connect the opposite frames. Shorter radial threads are laid down from the centre (orb) out to the frames. The web looks like a manysided wheel with numbers of spokes (Fig. 67).

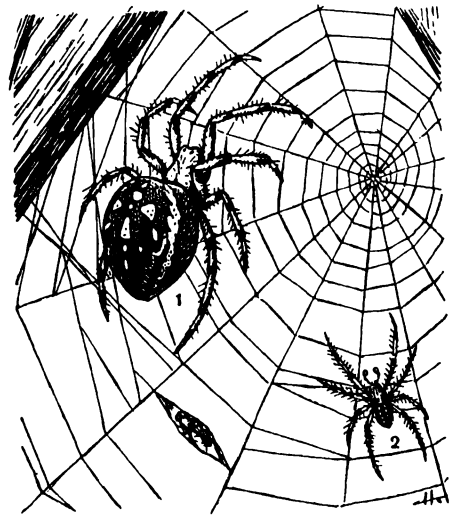


Fig. 67. Garden Spiders and their cobweb.
1. Female. *2.* Male.

This done, it starts secreting adhesive silken threads.

Making spiral movements from the orb it crawls from one "spoke" to the next, glueing the fine, sticky threads together with the help of its teat-like spinnerets. As a result, an increasing number of angles are formed.

Finally, a "telegraph line" is stretched from the orb to the spider's hiding place.

Food. When a spider bites a fly it injects into it an effective poison together with digestive juices. The juices dissolve the fly's inner organs reducing them to a semi-fluid mass. After a time, the spider returns to its prey and sucks out the contents, leaving nothing but the empty, chitinous covering.

Reproduction. In autumn the female spins a tiny golden-yellow ball-like silk cocoon, in which it lays several scores of eggs. It then dies.

If you catch a large female in autumn and keep it in a test tube for some time, you will be able to watch the cocoon- and egg-laying process for yourself.

Having survived the winter (or artificially-arranged cooling period in your test tube experiment), the eggs hatch into young spiderlings. The spiderlings have never seen a web; much less have

they had a chance to learn how to construct one, and yet they behave at once like adult, experienced spiders, "spinning" and "weaving" with the greatest skill. This shows convincingly that the instinctive behaviour of animals is hereditary.

Questions: 1. What are the differences between the external anatomies of spiders, crayfish, and beetles? 2. How do spiders catch food? 3. How do they construct their cobwebs? 4. Why do we say that instinct is hereditary? What evidence supports this assertion?

§ 31. FOREST TICKS

Anatomy and Habits. Forests cover nearly half the area of the Soviet Union. Many people, such as timber-fellers, shepherds, mowers, hunters, mushroom- and berry-pickers, spend much time in the forests. Tired urban dwellers like to camp in the woods and groves.

However few of them are aware of the danger to which they are exposed when they come in contact with a small animal called the *Forest Tick* (Fig. 68).

Its body is dark-brown and unsegmented. When the animal is hungry it is somewhat flat and the size of a flaxseed. The tick possesses four pairs of jointed walking legs, with very sharp claws—a clear indication that it is related to the spider, and not to the six-legged insects.

When hungry, the tick runs fast, extending its front pair of legs, which carry the organs of *touch* and *smell*.

It is emaciated and hungry when it emerges from its winter shelter in the soil in early spring, before the snow has melted. It crawls to a path frequented by people and animals, then climbs onto a shrub or a stalk of dry grass and waits with its first pair of legs extended. Even a slight breeze is sufficient to bring the scent of man, animal or bird to it. It then begins to move its front legs frantically, attaches itself to a passing host by means of its sharp claws, and forces its proboscis through the skin. A man may not even feel the bite and walks on unaware that he has become the host of *an external parasite*.

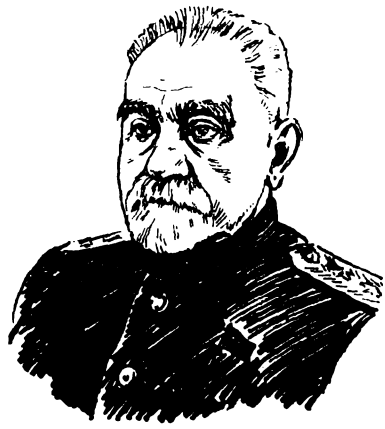
Fig. 68. Forest Tick.

The tick sucks the host's blood for two or three days. It can absorb quite large quantities

because its oesophagus is voluminous and its body covering can stretch till it is as big as a cherry.

When full of blood, the tick drops off the host and falls to the ground. Some time later, the female selects a suitable place and lays several thousand tiny eggs.

Encephalitis. Ticks are harmful not only because of their blood-sucking habits. They also transmit a very grave disease, taiga encephalitis (inflammation of the brain). This constitutes a serious danger to people living in or travelling through the taiga.



Academician Evgeny N. Pavlovsky.

The early symptoms are severe aches, fever, poor appetite, loss of weight, lack of energy, and sleepiness. Paralysis often results, and sometimes death.

The cause of the illness remained a mystery for a long time but in the thirties the Soviet Government allocated funds to fit out a number of expeditions. One group was led by Academician Evgeny N. Pavlovsky, a famous scientist, who had devoted his life to unravelling the mysteries of nature and trying to make nature serve man. Academician Pavlovsky spent many years studying various harmful animals, parasites and carriers of infectious diseases.

It was established that in the Far East epidemics of encephalitis commonly occurred in early spring, i.e., when swarms of blood-sucking insects were not yet present in the forest and therefore could not be the carriers of encephalitis. Spring, too, was when the ticks crawled out of their winter shelters in search of food and hosts. The members of the expedition caught hungry ticks in the taiga and allowed them to suck the blood of mice. The experiments caused paralysis, one of the symptoms of the disease.

It was discovered that when it bites a host the tick transmits in its saliva the encephalitis virus, having obtained it from the blood of animals or birds. The infection of human beings takes place in the same way.

Control. The selfless and heroic efforts of the Soviet scientists helped to discover the cause of the disease. People began to take more care and to apply to their skins preparations that were repellent to the ticks. Medical experts developed anti-encephalitic vaccines. There are now few cases and mortality has been reduced.

People working in forested areas should never forget the danger of ticks. It is much easier to protect oneself from encephalitis than to be cured of the disease. When preparing to go to the forest, people should put on overalls made of robust fabric and should regularly examine their bodies and clothes for the parasite.

If you find a tick biting you remove it carefully by easing it slightly sideways. If you leave the proboscis in your skin the wound will cause pain. A good way of getting it off is to drop a little oil or kerosene on it. The tick will then immediately withdraw its proboscis.

Questions: 1. How are people infected with encephalitis? 2. How can the disease be controlled?

§ 32. CLASSIFICATION OF THE ANIMAL KINGDOM

Phyla. Each large group of animals, for instance, the Protozoa, Coelenterata, Worms, Molluscs and Arthropoda, is called a *phylum.*

The *Phylum Protozoa* consists of single-celled animals.

The *Phylum Coelenterata* consists of simple multi-celled animals with radial symmetry, whose enteron (body cavity) communicates with the animal's environment through one opening only.

The *Worms* have a more complex anatomy. They are also multi-celled, but have no legs. They are subdivided into three phyla:

Annelida (e.g., the Earthworm);

Nemathelminthes, or *Roundworms* (e.g., the Ascaris);

Platyhelminthes, or *Flatworms* (e.g., the Pork Tapeworm).

The *Phylum Mollusca* is composed of animals having a shell, mantle and foot.

The *Phylum Arthropoda* encompasses animals having segmented legs and chitin-covered bodies.

The majority of the arthropods are not large. True, some of the beetles may grow as big as a hen's egg, and some butterflies may have a wingspread as wide as two pages of your textbook, whereas some sea crustaceans may have a body as big as a rabbit. But these species are much smaller than the vertebrates, whose growth is not hampered by their skeletons.

Arthropods play a very important part in the life of nature and man. They belong to the largest phylum which includes, among others, over a million species of insects.

Class. The phyla are subdivided into *classes.*

The beetles, moths, butterflies, bugs, mosquitoes, flies, and bees, described in this chapter, belong to the Class Insecta, coming under the Phylum Arthropoda.

An insect is an animal whose body is made up of three parts—a head, a thorax, and an abdomen. It has three pairs of jointed limbs; breathes through a trachea; has a pair of antennae (feelers) to act as an organ of sense; and sees by means of compound eyes.

The Fresh-water Crayfish, Daphnia (Water-fleas) and Cyclop belong to the *Class Crustacea.* This class is made up of animals which for the most part inhabit seas, rivers, ponds and lakes. Their organs of respiration are the gills. Their bodies are divided into a cephalothorax and an abdomen. Each of them has two pairs of antennae; most possess two compound eyes. The appendages consist of two branches and differ in number. The majority of crustaceans are useful to man.

The ticks and spiders belong to the *Class Arachnida.*

They are characterized by a definite number of jointed limbs (four pairs). The compound eyes and antennae are absent. Some are totally blind, others carry simple eyes, which are very, very small. The body is commonly divided into a cephalothorax and an abdomen. Sometimes they are combined into one whole. Many species are very harmful to man.

Origin. The Insecta, Crustacea and Arachnida have certain features in common. Their bodies are covered with a chitinous exoskeleton and they have jointed limbs. These features are not accidental but are a clear indication of relationship. This is why they are included in one phylum, the Arthropoda.

Traces of relationship can also be found if you compare the Arthropoda and the Annelida. Both phyla have segmented bodies, a well-developed ventral nerve cord and a dorsal blood vessel. This is a very important point.

Questions: 1. What animals belong to the Arthropoda? 2. What phyla of animals do you know? 3. What classes are there among the Arthropoda? What are the differences between them?

CLASS FISHES

§ 33. FRESH-WATER PERCH. GENERAL CHARACTERISTICS

Habitat. The general characteristics of the fishes will be better understood if we study a typical example, for instance, the Fresh-water Perch, which lives in rivers and lakes, where it can find everything necessary for its existence: fresh water, food, dissolved oxygen for respiration, and suitable spawning places.

The Perch is an expert swimmer. Its body—elongated, flattened from side to side, pointed at the anterior end, and narrowed towards the tail—is perfectly fitted to move swiftly through the water.

External Structure. The *head* is united, without a flexible neck, to the *trunk*, which tapers into a powerful, muscular *tail*. These are the three parts (Fig. 69). The anus lies on the border between the last two. The tail, which is the main propelling organ, accounts for about a third of the body length, and is provided with the *caudal* fin (*tail-fin*). The perch propels itself forward by moving its trunk and finned tail from left to right.

More complicated movements—such as changing its course from one side to the other or maintaining balance, i.e., dorsal side up—are achieved with the help of the *unpaired* and *paired* fins. The unpaired fins include, besides a tail-fin, two *dorsal* fins (back fins) and one

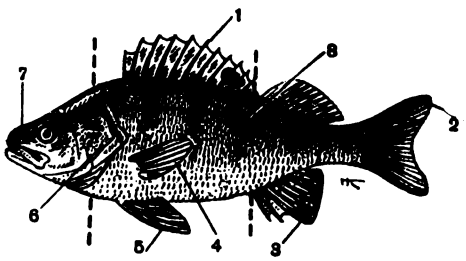


Fig. 69. Fresh-water Perch.
1. Spiny dorsal fin. *2*. Caudal fin (tail-fin). *3*. Anal fin. *4*. Pectoral fin. *5*. Ventral (pelvic) fin. *6*. Gill-cover. *7*. Nostrils. *8*. Lateral line. (The dotted lines separate the head, trunk and tail.)

anal fin on the underside which lies immediately behind the anus; the paired ones are: the *pectoral* and *ventral* fins.

The fins consist of numerous bony spines, called *fin-rays*, which support the folds of thin skin. In the first dorsal fin the rays are sharp and hard; they can stand upright and are used as a weapon against enemies. The others are soft.

From head to tail the body of the Perch is covered with *horny scales* arranged in such a way that they overlap like roof tiles and afford protection for the underlying organs and at the same time allow great freedom of movement. The scales are covered with a layer of slime which reduces friction and is secreted by special skin glands.

Coloration. The Perch has an olive-brown back with dark cross-bands on its sides which are a somewhat lighter colour. On the underside it is pale yellow.

This colour pattern provides excellent camouflage: the olive-brown back of the Perch is almost invisible, viewed by fish swimming above, against the dark background of the bottom; while viewed from below, its yellowish belly tones in with the lighter colours of the upper layers of water. The dark cross-bands can be easily identified as shadows cast by water weeds, where the Perch generally hides waiting for its prey.

Coloration differs depending on the natural environment. In quiet-flowing forest rivers, where the water looks dark due to the presence of silt and decayed organic debris on the beds, the Perch has developed darker colours. In swift, turbulent streams with sandy beds, its colour pattern is lighter. The coating is so designed as to harmonize with the natural surroundings.

The *camouflage* (*deceptive coloration*) helps the Perch to approach its prey without being noticed, and also to hide from its enemies.

Sense Organs. The Perch feeds on moving prey. With its mouth opened wide, it swallows smaller fishes and small water life. At the same time, it is preyed upon by larger fishes, for instance, the pikes.

The sense organs, which are connected with the brain by means of nerves, are of great service to the Perch in catching its prey and hiding from its enemies.

The *eyes*, i.e., the organs of sight, are found on both sides of the head. The Perch can see surrounding objects, but only at short distances. It differs from land vertebrates in that it has no eyelids

Fig. 70. A diagrammatic view of the lateral line organs.
1. Lateral canal. *2*. Opening. *3*. Sensory cell. *4*. Nerve.

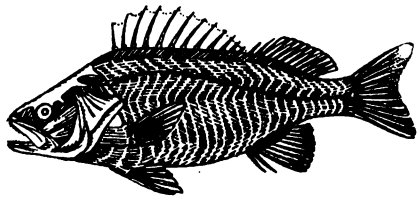


Fig. 71. The muscles of the Perch. The lateral line is traced in black.

and the eyes are constantly washed by water.

The *organs of smell* are found in the head, in front of the eyes. These are two little capsules enclosing highly-sensitive cells from which nerves pass to the brain. Each organ of smell has two openings, known as the *nostrils.*

The *organs of hearing* are invisible from the outside. They are situated in the skull and are likewise linked by nerves with the brain. Sound vibrations are transmitted to the "inner ear" by the bones of the skull.

The *organs of touch* and *taste* are represented by groups of sensory cells scattered all over the body-surface, each connected by nerves with the brain.

The *lateral line organs*, which are typical of the fishes, lie on both sides of the body (Fig. 69). When viewed through a magnifying lens they appear as an array of dots (or short lines). Each dot marks the exterior opening of a short canal connected with a long lateral canal in the skin.

The canal is lined with sensory cells which are linked with the brain by nerves (Fig. 70). The lateral line organs react to water vibrations and pressure. The Perch uses them for detecting the direction and force of the water flow, the depth of submersion, and nearness to solid bodies. If the nerves of the lateral line are cut, the fish loses the ability to coordinate its movements and bumps into objects in its path.

The study of the external structure of the Perch shows convincingly that it is an animal adapted to live in water.

Questions: 1. How does the Perch move in its natural environment? 2. Why do we regard the pattern of the Perch as a case of deceptive coloration? 3. What sense organs help the Perch to exist in its surroundings? 4. Why do we say that the Perch is adapted to live in water?

§ 34. MUSCLES AND SKELETON

Muscles. The *muscles* of the Perch lie under the skin (Fig. 71). They become shorter when contracted and longer when relaxed. When they contract the parts of the body to which they are attached are drawn closer together, i. e., are made to move.

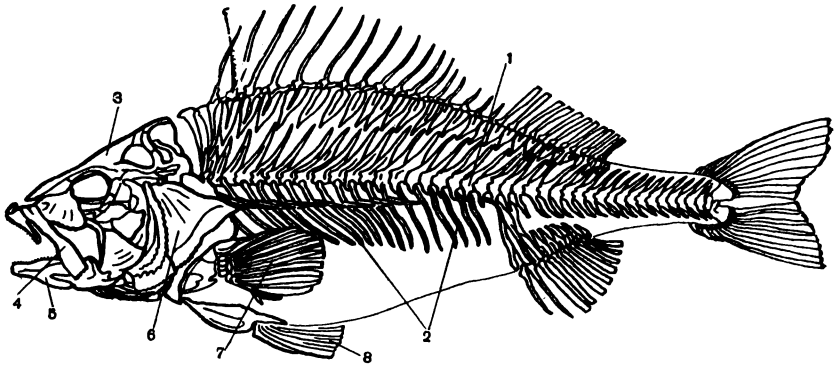


Fig. 72. The skeleton of the Perch.
1. Backbone. *2*. Ribs. *3*. Cranium (Braincase). *4*. Upper jaw. *5*. Lower jaw. *6*. Gill bony plates. *7*. Pectoral fin-rays. *8*. Ventral (pelvic) fin-rays.

The muscles on the back and in the tail are particularly powerful. When they contract, the fish moves forward. Special muscles, which are also well developed, control the movements of the fins.

Skeleton. The *bony skeleton* lies immediately under the muscles (Fig. 72). It is known as the *internal* skeleton (*endoskeleton*), as distinct from the exoskeleton of the arthropods and molluscs.

The skeleton is made up of a great many bones, and can be divided into: 1. the backbone (vertebral column) which runs lengthwise from the head to the caudal fin; 2. the skull; 3. the supports of the unpaired fins; 4. the supports of the paired fins.

The vertebral column (*backbone*) is composed of a series of isolated bones, called the *vertebrae*, united firmly and yet allowing a great deal of freedom of movement. It provides support for the entire body and is sufficiently flexible to be bent sideways during swimming.

Each individual vertebra is made up of a *centrum* (*body*) and a protruding arch (Fig. 73). Arranged one after the other, they form the spinal *canal* holding the spinal cord.

In the process of its development from the egg, the fish does not have a backbone at first, but a stiff supporting rod, called the *notochord*. Later, vertebrae begin to grow around. Remnants of the notochord are found in the body of the adult Perch in the form of small transparent balls of jelly.

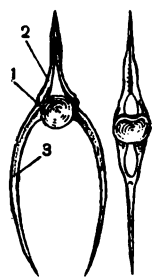


Fig. 73. Fish vertebrae.
Left—thoracic vertebra; *right*—tail vertebra.
1. Centrum (body). *2*. Arch. *3*. Rib.

The vertebrae support a system of *ribs*—elongated bones which run down from both sides of the body, protecting the inner organs.

The numerous bones in the head form the *skull*, which consists of a *braincase* (cranium), to protect the brain, and the bones surrounding the mouth and the pharynx (jaws, gill-arches, gill-covers).

In the *fins* are numerous small bones.

The skeleton holds the body to a definite shape and serves to protect the inner organs. With the muscles, which are fixed to it, the skeleton forms the *motor apparatus* of the Perch.

Questions: 1. What role do the muscles play and how do they cope with it? 2. Which muscles are the most powerful, and why? 3. What sections make up the skeleton? 4. What can you say about the backbone? 5. What is the advantage derived from the flexible joining of the vertebrae? 6. Where are the ribs and what is their importance?

§ 35. NERVOUS SYSTEM

Structure. The function of the nervous system in the Perch is the same as in all the other animals you have studied. It is a means of communication between the organs and of receiving messages from the outside world.

The nervous system of the Perch extends along its back (remember the arthropods), and consists of the brain, the spinal cord and a number of nerves which connect the brain and the spinal cord with all the other organs.

The *brain* is enclosed within the cranium. If viewed from above (Fig. 74), it is divided into the *forebrain* with a number of nerves passing forward to the organs of smell; the *midbrain* which is the best developed; the *cerebellum*, and the *afterbrain* (*medulla oblongata*), which gradually passes into the spinal cord. The hind part of the forebrain is separated from the midbrain by the *betweenbrain* (*diencephalon*), which gives rise to the optic nerves that run down to the eyes. It is poorly developed in the Perch and invisible from above.

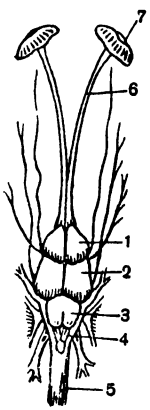


Fig. 74. The brain of the Perch (as viewed from above). *1*. Forebrain. *2* Midbrain. *3*. Cerebellum. *4*. Afterbrain (medulla oblongata). *5*. Spinal cord. *6*. Olfactory nerves. *7*. Organs of smell.

The *spinal cord* is enclosed in the spinal canal and extends like a long rod along the entire length of the body.

The *nerves* run like white threads from the brain and the spinal cord to the sense organs, muscles, and other internal organs. They are divided into two groups:

sensory nerves and *motor nerves*. The first are responsible for conveying messages (impulses) from the sense organs and other organs to the brain; the second work in the opposite direction, carrying impulses from the brain to the organs.

Reflex Action. The behaviour of the Perch is based on reflex action. Touch it and it will swim away fast, prompted by the *defence* (or *protective*) *reflex*, the same that caused the Hydra to contract its body or the earthworm to crawl away from a match.

Feeding calls forth the *food reflex*: on seeing a little fish the Perch darts in its direction to catch it. These actions take place because of the following processes that occur in its nervous system: outward stimulation affects the endings of the optic nerve, which are in the eyes of the Perch; the message is passed along the nerves to the brain; the brain transmits an "order" to the muscles of the body and the tail; the latter contract, and the Perch swims swiftly after its prey. Another message is simultaneously conveyed to the muscles responsible for the movements of the mouth-parts.

These reflexes are hereditory and *unconditioned.*

Fishes can also develop another kind of reflex in the course of their lives. If you feed the inhabitants of an aquarium in one particular corner all the time, drumming on the wall with a little stick as you do, the fish will gradually learn to swim up to the place as soon as the drumming begins. Food will become associated with a definite sound. This is an acquired reflex which appears only if feeding and the sound of drumming come together. It can also be developed by lighting a lamp in the corner as soon as food is "served". Reflexes which are developed in the animal's lifetime, and only under certain conditions, are known as *conditioned reflexes.*

Conditioned reflexes are not stable. If, for instance, you stop drumming on the aquarium wall, or do it at some other than feeding time, the fish will cease to swim up: the conditioned (acquired) reflex will be lost.

Questions: 1. What can you say about the nervous system of the Perch? 2. What processes take place in the nervous system of the Perch when it darts forward to catch its prey? 3. Can you suggest another way of developing a conditioned reflex in a fish? 4. What is the difference between conditioned and unconditioned reflexes?

§ 36. FUNCTIONAL SYSTEMS OF THE PERCH

When one side of the trunk is removed, the body cavity, containing the digestive, circulatory, excretory and reproductive systems can be seen. The respiratory organs, the gills, lie under the gill-covers, outside the body cavity. Now, in order to gain a more

thorough knowledge of the vital processes that take place within the fish, let us study each organ and its functions separately.

Food and Digestion. The Perch catches its prey in its *mouth* which is abundantly supplied with sharp, pointed teeth. Without being chewed, the food is passed through the *pharynx* and the *oesophagus* into a fairly roomy *stomach*. Embedded in the walls of the stomach are microscopically small glands which secrete *gastric juice*.

The food, partly digested by the juice, passes into the *intestine*. The walls of the intestine contain special glands which secrete *intestinal juice*. The intestine also receives *bile*, which is the product of the liver. The *liver*, large and reddish-brown, is found near the stomach, and is easily observed. The *gall bladder* contains bile which is passed into the intestine when the latter contains semi-digested food.

Under the influence of the gastric and intestinal juices and the bile the food is digested, i.e., transformed into simple, soluble materials which pass through the walls of the intestine into the blood stream. The undigested remains are passed out through the anus.

The mouth, pharynx, oesophagus, stomach, intestine and liver form the *digestive system*, which plays a very important part in the life of a living organism.

Air-bladder. The *air-bladder* (or *swim-bladder*) is an elongated silvery-white sac, which lies above the stomach. It cannot be removed from the Perch but can be easily taken from species like the roach or carp. It has two parts.

The air-bladder is supplied with gases—nitrogen, oxygen and carbon dioxide. It can contract and expand. When it contracts the specific body-weight of the Perch increases somewhat and the fish sinks, but when the air-bladder expands the fish rises again.

Respiration. Respiration is as vital and important as taking food. During respiration an exchange of gases takes place: oxygen enters the body, carbon dioxide is passed out.

The Perch, which lives in rivers and lakes, inhales oxygen dissolved in water. If you place the Perch (or some other fish) in boiled water which lacks oxygen it will begin to suffocate, rise out of the water gulping for air, and soon die.

The organs of respiration are the *gills* (Fig. 75), which are situated under the *gill-covers*. They consist of bony *gill-arches* on which are bright-red *gill fringes*. Between

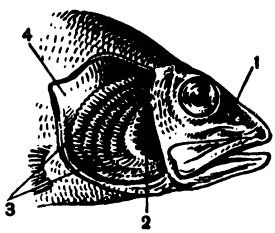


Fig. 75. Perch head.
1. Nostrils. *2*. Gill rakers. *3*. Gill fringes. *4*. Gill-cover (partly removed).

the arches are the *gill slits*. The gill-covers are movable. This ensures a never-ending flow of water over the gills. Water is taken in at the mouth, passes through the gill slits, bathes the gill fringes, and is expelled from under the gill-covers. The dissolved oxygen in the water passes into the blood through the thin walls of the gill fringes and those of the numerous blood vessels. Simultaneously, carbon dioxide is removed from the blood stream and passed out into the water.

When exposed to fresh air, the gill fringes quickly dry up and lose their ability to absorb oxygen. This is why fish cannot live out of their natural environment, i.e., water.

Circulatory System. The nutrient substances extracted through the walls of the intestine and the oxygen from the gill fringes are carried by the blood stream to other parts of the body along the blood vessels. Blood circulation is maintained by heart contractions. The circulatory system consists of the heart and the vessels (Fig. 76).

The *heart* lies in the anterior end of the body cavity, behind the head. It looks like a muscular sac and has only two chambers—an *auricle* and a *ventricle*. It belongs to the category of *two-chambered* hearts. When the muscles lining its walls contract, the heart becomes smaller, and blood is pumped into the *vessels*.

The canals through which the blood is carried are of different kinds. They are known as arteries, veins, and capillaries. The *arteries* carry the blood from the heart to the organs. The blood returns to the heart through the *veins*. The *capillaries* are minute blood vessels which lie between the arteries and the veins, and cannot be seen without the aid of a microscope.

The blood returning to the heart through the veins first enters the auricle which contracts and passes it into the ventricle. A contraction of the ventricle forces the blood into the artery which carries it back to the gills. There carbon dioxide is given off in exchange for a fresh supply of oxygen. Then the blood flows into the main artery which runs along the backbone towards the tail. The artery branches out into a multitude of smaller vessels, which go to the organs and further branch out to make a dense network of capillaries.

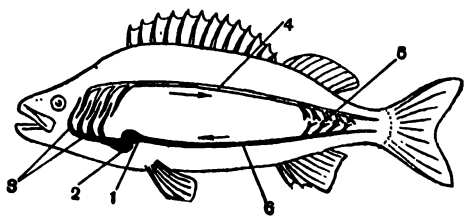


Fig. 76. The circulatory system of the Perch.

1. Auricle. *2*. Ventricle. *3*. Bronchial arteries. *4*. Dorsal aorta. *5*. Capillaries. *6*. Vein.

In the capillaries oxygen and nutrient substances, necessary to nourish the cells of the organs, are passed out of the blood, and carbon dioxide and other wastes, which are to leave the body, are picked up. From the capillaries the blood flows into the veins and back to the heart.

Thus, the blood is pumped through the vessels in a *closed circuit.* The continuity of its flow is of the utmost importance. It provides a constant supply of necessary nutrient substances and oxygen to the organs, and the withdrawal of carbon dioxide and other wastes. The flow of the blood links the organs in a common circulatory system.

Excretory System. Apart from carbon dioxide which is excreted through the gills, other waste matter is formed in all the organs of the Perch. It is absorbed by the blood stream and delivered to the excretory organs, the kidneys, to be passed out of the body in the form of urine.

The pair of *kidneys* look like two short reddish-brown ribbons, and are found in the upper part of the body cavity, under the backbone. Urine flows from the kidneys through the *ureters*, which lead into the *urinary bladder.* The latter has an opening behind the anus.

Metabolism. The functional systems in the body of the Perch indicate the presence of complex, vital processes. Nutrient substances, formed as a result of digestion in the stomach and intestine, are absorbed by the blood and carried to all parts of the body. They pass through the thin walls of the capillaries, enter the cells, and are assimilated there, i.e., transformed into matter which makes up the body of the Perch.

Simultaneously, the blood supplies all the cells with oxygen picked up when flowing over the gill fringes. Oxygen is constantly utilized to break compound matter into simple matter. This releases the energy necessary for the activities of all the organs. The breaking down leads to the formation of carbon dioxide which is removed through the gills, and of other waste products, which are excreted through the kidneys.

These complex processes, which occur in the body of the Perch, are known as *metabolism.* During the process of metabolism, building materials are received by the organism from without (food, oxygen) and waste products (carbon dioxide, urine) are excreted.

As long as this process continues, the fish remains alive. As soon as metabolism stops, life ends, and the Perch dies. Metabolism is an essential feature of all living organisms. It takes place in all animals and plants.

In the fishes, the process of metabolism is very slow. The heart contracts no more than 20 times per minute. The blood does not contain very much oxygen. The temperature of the body is not

stable: it is about the same as the surrounding water. In cold weather it is low; when the temperature of the water goes up, the body temperature rises.

Questions: 1. How does the Perch digest food? 2. What is the importance of the gills? What is their structure? 3. What is the role of the blood? 4. How does the blood circulate? Describe the process. 5. What is the importance of the excretory organs? What do they consist of? 6. What is understood by metabolism in the body of the Perch?

§ 37. REPRODUCTION AND LIFE-CYCLE

Reproductory Organs. The sexes are separate, but in outward appearance the males and females are alike. The anatomical difference can be determined only by dissection.

The females have a large *ovary* in which female germ cells—*eggs*, or *ova*—develop. The eggs have a large quantity of yolk.

A pair of white elongated *testes* in the males provide male germ cells—extremely active and mobile *spermatozoa*, or *sperms*.

Both the ovaries and testes have special exterior openings lying behind the anus.

Breeding Habits. The egg-laying, or *spawning*, takes place in spring, when the weather is warm (end of April and early May). The Perch gather together in great shoals in shallow quiet backwaters overgrown with weeds, where the water is sufficiently warm.

The eggs laid by the females remain glued together in long strings which hang on the weeds (Fig. 77). The males excrete jellied fluid containing sperms.

Once released into the water, the sperms swim actively towards the eggs; the different cells fuse, and *fertilization* takes place. The nuclei and protoplasm of the sperms and ova unite. Two cells merge into one, giving rise to a new living organism.

Development. The fertilized egg of the Perch divides into two cells. The cells re-divide—so that four are formed. This process continues until a *multi-celled embryo* is formed.

The embryo develops tissues and organs. In about 5 or 6 days, it becomes a small (0.5 cm. long)

Fig. 77. A string of Perch ova on r[illegible] weeds.

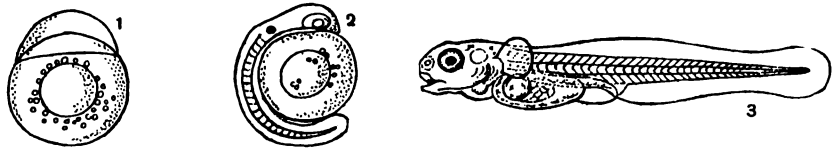


Fig. 78. The stages of development.
1. Egg (ovum). *2.* Embryo. *3.* Larval fish.

larval fish (Fig. 78), with a yolk sac on its belly—the remainder of the food reserved in the egg for its development. When the supply runs out, the larva begins to feed on microscopically-small weeds, infusorians and tiny crustaceans (Daphnia and Cyclops), and grows into a *young fish* (*small fry*) which is very much like the adult Perch.

Shallow backwaters are most suitable for spawning: the temperature of the water is higher; there are plenty of weeds on which to hang the egg-strings; the plants provide a rich supply of oxygen. As a rule, there is no shortage of tiny living organisms for food for the larval fish and small fry.

And yet these relatively favourable conditions hold hazards for the development of the young. Some of the eggs may be left unfertilized; many of the eggs are devoured by other fishes. Many larval fishes and small fry are devoured by other animals. Finally, there is always the possibility that the water level will fall due to hot weather, or oxygen supply will prove insufficient.

The only one way to escape extinction is the laying of tremendous numbers of eggs. One ovary, which weighs about 200 gr., normally contains between 200,000 and 300,000 eggs. The number of sperms discharged by the male Perch is immeasurably greater.

On the other hand, some fishes lay very few eggs, for instance, the Stickleback (only 60 or 70). But these eggs are deposited in nests composed of grass or weeds, and are protected by the male.

The behaviour of the Perch at spawning time is very complex and may lead to the conclusion that it is even conscious. In fact, it is prompted by a chain of hereditory unconditioned reflexes. Everything is performed *instinctively.*

Questions: 1. What is understood by fertilization? Describe the process using the Perch as an example. 2. What changes does a fertilized ovum undergo in its development? 3. What conditions are essential for the development of the ova and the young fish? 4. Why does the Perch lay so many eggs?

§ 38. OTHER VARIETIES

The Pike and the Sazan. Scientists have described up to 20,000 different species of fishes which are living today. Many have been found fossilized—they have lived on our planet but have become extinct.

Some fishes inhabit fresh-water rivers and lakes; others prefer the salt water of the seas and oceans. There are fishes which keep close to the bottom; others swim nearer the surface. Some are vegetarians, adding to their diet slow-moving animals; others catch swiftly-swimming prey.

Their different ways of living have influenced their anatomy. You will notice these differences if you study the general characteristics of a few different species.

Look at the pictures of the Pike and the Sazan, which are found in most of our rivers, and compare them (Fig. 79 and Fig. 80).

The *Pike* is long and slender, and has a big head narrowed at the tip. The *Sazan* is broad and thick, with a small head.

The Pike has an enormous mouth equipped with rows of formidable-looking teeth, curved backwards. Because of their teeth, Pikes should be handled very cautiously even when caught on a fishing line. The Sazan, on the other hand, has a small mouth and no teeth.

Why is the difference so great? After all, both varieties live in the same rivers.

The explanation is to be found in their diets. The Pike and the Sazan eat different food and have different methods of obtaining it.

The Pike is carnivorous. It eats fish. You can see it sometimes, motionless among the weeds. As soon as another fish swims along, the Pike darts forwards like an arrow, its mouth open wide. Pikes have been known to attack ducklings, water rats, and other animals. The powerful tail, near which the soft dorsal fin and the anal fin are attached, as well as the long, slender body, help the Pike to swim swiftly in pursuit of its prey. The sharp teeth, curved backwards, hold the victim so fast that even the slimy covering of its body does not help.

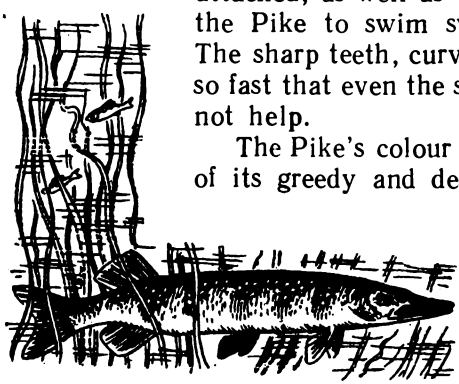


Fig. 79. Pike.

The Pike's colour pattern facilitates the pursuit of its greedy and destructive habits. It can easily conceal itself. It is mottled green, with dark bands, and difficult to distinguish from the weeds, among

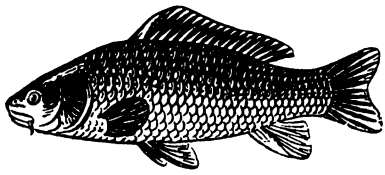


Fig. 80. Sazan.

which it hides when waiting for its prey.

The *Sazan* has totally different habits. It does not hunt other fishes, but feeds on a mixed diet of insect larvae, molluscs, worms, and even vegetable matter.

The Sazan locates its food in the river mud and silt by means of two sensitive feelers on its upper lip. The mouth is small and there are no teeth. It has no need of them. Down in its pharynx are several blunt teeth, used to crush the shells of molluscs and grind vegetation.

The shape of the Sazan's body is also different from that of the agile Pike. It is taller and thicker, and the tail is rather weak.

The peculiarities in anatomy and habits are due to the fact that their ancestors did not live in identical environments. They ate different food and developed their own methods of obtaining it.

Questions: 1. What structural peculiarities indicate that the Pike is greedy and a voracious hunter? 2. How is the Sazan distinguished from the Pike? Why are they different?

The Shark and the Plaice. Let us study two species of fish—the Blue Shark and the Plaice (Fig. 81 and Fig. 82), found in almost all seas but having very little in common.

The *Blue Shark* has a long cylindrical body, narrowed at both ends. The Plaice is broad, flat, and resembles an oval plate bordered with fins. The origin of these peculiarities will become clear if we study their ways of life.

The Shark lives in the vast expanses of the various seas of the world. It is carnivorous, like the Pike. It does not lie in wait for its prey, however, but hunts for fish in the depths of the sea. Its task is comparatively easy for it can develop a speed of 35 km. an hour. Swift locomotion is facilitated by the shape of its body, which is long and slender, suited for rapid movement. The powerful tail carries a caudal fin, the dorsal lobe being larger than the ventral.

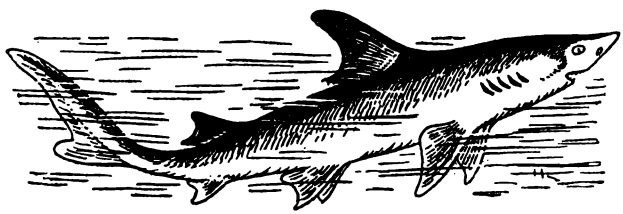


Fig. 81. Shark.

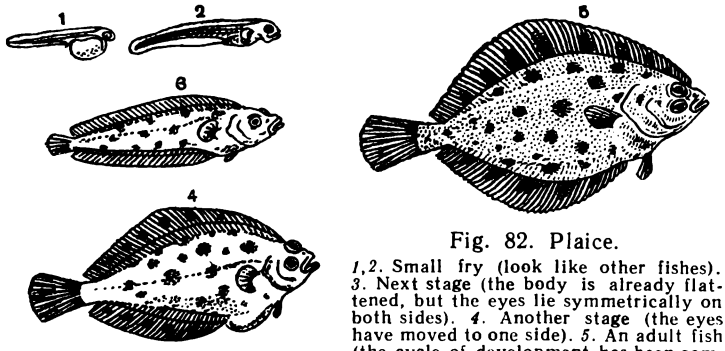


Fig. 82. Plaice.
1, 2. Small fry (look like other fishes). *3.* Next stage (the body is already flattened, but the eyes lie symmetrically on both sides). *4.* Another stage (the eyes have moved to one side). *5.* An adult fish (the cycle of development has been completed).

A Shark landed on the deck of a ship may break a fisherman's leg with a lash of its tail.

The Shark has sharp teeth with which it catches and holds its slippery prey.

The *Plaice* has totally different habits. Usually, it lies on its side on the sea bed, and feeds on bottom-living creatures: worms, molluscs, crayfish. In the pharynx are a pair of broad plates with which it crushes the shells of molluscs and the hard carapace of the crayfish.

The Plaice does not swim upright, as do other fishes, but lies on one side. It seldom swims but when it does it keeps on its side.

Because of its habit of lying on one side, the Plaice has developed a peculiarity: both eyes and the nostrils are on the upper side of its head, and the mouth is twisted in the same direction.

The colour pattern is also interesting. One side of the body matches the ground—the one that lies uppermost, and not the back, as in other fishes. The opposite side, which is buried, is whitish.

It is interesting that when it hatches the young Plaice has a common shape and its eyes are in the normal position (Fig. 82). At first young Plaice live near the surface of the sea. Gradually, the left eye passes over to the right side. This shows that the ances-

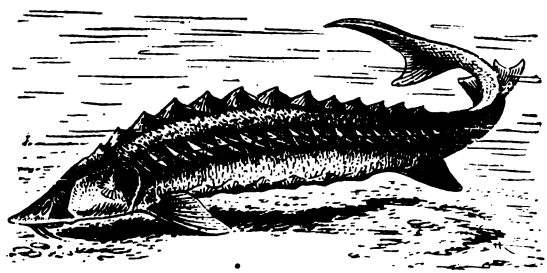


Fig. 83. Russian Sturgeon.

tors looked and behaved like other fishes, and had eyes on both sides of the head. Modifications in their anatomy have taken place under the influence of the environment in which they lived, i.e., the sea bottom.

Questions: 1. What structural features indicate that the Shark is an expert swimmer? 2. How has the Plaice adapted itself to living on the bottom of the sea? 3. What is there of specific interest in the development of the Plaice?

The Russian Sturgeon. You have read about some fresh-water and sea fishes. There are certain species, however, which are both fresh-water and marine. One of them is the *Russian Sturgeon* (Fig. 83), which is found in the Caspian and Black seas.

At spawning time, Russian Sturgeon swim to the upper reaches of the rivers. Having spawned their eggs they return to the sea, where they are followed by the young some time after hatching.

Fishes, which spend one part of their life in the sea and the other in the rivers, are known as *migratory.*

The Russian Sturgeon are mostly large fishes, the body being about 1 m. long. Their flesh is very good to eat; black caviar which is prepared from their eggs is considered a delicacy and is very expensive. Their food consists of worms, molluscs, and insect larvae, which they find in the bottom mud. Sometimes they swallow small fish as well.

The Sturgeon has no body skeleton, just a few flat bones to protect the cartilaginous skull from above. The backbone is represented by a *notochord*, a solid supporting rod, which extends through the body and the tail and has small cartilaginous *arches* under it. There are no fully-developed vertebrae. Fish having such skeletons are classified as *Chondrostei.*

The scales of the Sturgeon and the Perch are not alike. Along the Sturgeon's body are 5 rows of large bony plates, called "bucklers" (Fig. 83), while between the rows, on each side, are smaller ones, the size of a grain.

Question: Into how many groups can the fishes be divided, according to their habitats?

§ 39. FISHING INDUSTRY

Commercial Fishing. One of the first things learnt by the ancient people was the use of fish and eggs as food. Fish is eaten fresh, salted, smoked, pickled or canned. The fishing industry is of great importance. In the Soviet Union fishing is carried out in the seas, lakes and rivers. The catching of fish in great quantities

for sale is called *commercial fishing.*

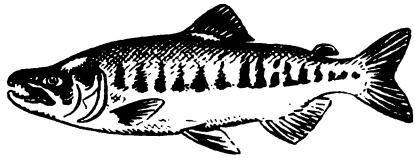


Fig. 84. Keta.

One of the most popular commercial fishes is the *Herring*, which is principally used salted and pickled. Herring are caught on a large scale in all the seas and oceans. (The most popular species come from Astrakhan, the Atlantic and Pacific oceans, etc.)

Northern fisheries are mostly concerned with the *Cod* and the *Sea Perch.*

Other fishes caught commercially include the *Vobla* (*Roach*), the *Pike Perch*, the *Golden Shiner*, *Sprat*, etc.

The Sturgeon family, which consists of *Beluga*, *Common Sturgeon*, *Starred Sturgeon* and *Sterlet* (or Small Sturgeon), are particularly prized for their tasty flesh and the black caviar. The same is true of the Salmon family (the *King Salmon* of the north, the *Humpback Salmon*, and the *Far Eastern Keta* — Fig. 84), the flesh and caviar of which are orange-red.

Fishing Methods. In the seas and oceans fish are caught by special ships carrying various equipment. Some fishes keep near the surface, others live closer to the bottom. Different methods and gear are required to catch each group. Bottom-living fish (Plaice, Cod, Sea Perch) are caught with *bag nets*, or *trawls* (Fig. 86). Surface-swimming fish (Herring) are caught in common nets and *purse nets* (Fig. 85). In the catching of some fish, for instance Sprat, light is used: powerful *electric lamps* are lowered into the sea to attract the schools of fish. Big hoses are directed into the zone of illumination, and the fish are pumped on deck. A sound zoological knowledge greatly helps the fishermen.

It is equally important to be able to locate the fish. Fish do not stay in one place. For instance, the Herring leave their usual habitat, the deep waters, at spawning time and approach the coasts, where the seas are shallow. Sturgeon and salmon breed in fresh water, i.e., rivers. In doing so, some varieties (for instance, the Far Eastern Salmon) gather in large schools. This moving from one place to another at certain seasons of the year is called migration.

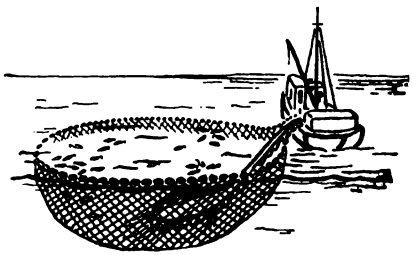


Fig. 85. A purse net.

Migrations are not always connected with breeding habits but may be due to food shortages.

In the latter half of summer, for instance, great numbers of Cod move to the Barents Sea from the coast of Norway to feed on fish.

A knowledge of the migratory habits of the fishes and the places where large numbers of them collect makes it possible to carry out fishing profitably.

Reconnaissance aircraft are used to locate fish shoals, which show up well from the air. The latest practice is also to use submarines.

Fish Protection. The regular annual increase of the commercial fish catch may lead to the exhaustion of fish resources. To prevent this, special measures are taken to protect fish and increase their numbers.

Regulations are imposed limiting the allowable times and places for commercial fishing. It is forbidden to use small-meshed nets, which would catch immature, young fish. The use of explosives is also forbidden because they do not discriminate and kill many undersized fish. From time to time, bans are imposed on fishing certain species and limits are fixed on the amount of the yearly catch. (This was done in the case of the Sturgeon in the Caspian Sea.) Measures are also taken to prevent poaching.

Fish hatcheries are being organized to carry out artificial fertilization of fish eggs. Some time before spawning, large specimens are caught. Eggs are carefully pressed out of the females, and seminal fluid out of the males, into a vessel. The eggs mix with the seminal fluid, and are fertilized. After this the eggs are placed in special containers with fresh, running water, where they develop. Upon hatching, the young fish are released in the seas and rivers.

Fish-breeding has acquired particular importance in connection with the hydro-engineering projects that are being built:

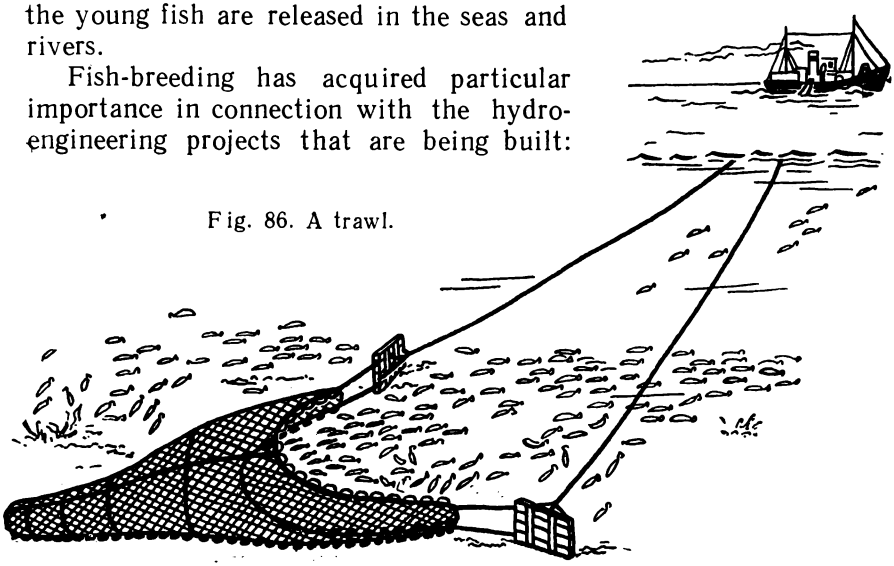


Fig. 86. A trawl.

dams prevent fish from swimming upstream for spawning. Special hoisting installations are therefore constructed near the hydropower stations to transfer the schools over the dams. Sometimes they are substituted by fish ladders.

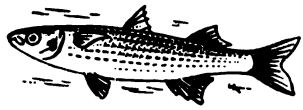


Fig. 87. Mullet.

There is a practice of transferring valuable species to new localities. This was done with the *Black Sea Mullet*, which was released in the Caspian Sea, reproduced well, and is at present caught commercially there (Fig. 87). The Far Eastern Salmon is faring well in the northern seas. The "newcomers" are accompanied by their favourite food. Thus, a species of marine worms has been introduced to the Caspian from the Sea of Azov.

Protection of Nature. In 1960 the Supreme Soviet passed a Law on nature protection covering the territory of the RSFSR. The Law provides for the protection and proper utilization of land, water and other natural resources, plants, animals, and the air. Typical landscapes, rare natural phenomena, picturesque resorts, forests, parks, green belts, and the suburban woods and groves must be protected and kept intact.

Animals of economic importance have also been placed under protection. To save them from extinction and increase their numbers special rules and time limits are set for fishing and hunting; valuable species of fish and fur-bearing animals are transported to new localities. A drive against predatory animals has been launched, as well as against those which cause or spread disease.

Other animals have also been protected from extinction, if they were not harmful to man, or if they were dying out.

The Law stipulates legal measures against people harming natural resources.

The protection of natural resources is a national responsibility. Much credit should be paid to the All-Russian Society for Nature Protection, which has many schoolchildren among its members. The protection of nature is the responsibility of every Young Pioneer and school pupil.

Questions: 1. What commercially-important fish are found in the seas and rivers of the Soviet Union? 2. What is done to increase their numbers? 3. Why is it important for fishermen to know the habits of fish?

The Carp. As well as releasing in rivers the small fry raised in fish hatcheries, Soviet experts have learnt to breed fish in ponds.

This mostly concerns the Carp (Fig. 88). The Carp family includes the *Common Carp*, whose body is entirely covered with scales; the *Mirror Carp*, with only three rows of large, silvery scales, and the *Leather Carp*, with just a few scales scattered here and there.

Carp Trade. When breeding Carp, account must be taken of their biological peculiarities, i.e., favourite habitat, food, spawning places, and behaviour in winter. On the basis of this knowledge, special conditions are provided that guarantee the utmost breeding efficiency.

The fishing farms build *chains of ponds fed by running water.* Each pond is assigned a special part in the breeding cycle (Fig. 89).

Adult species selected for breeding winter in deep *parent ponds.*

In spring they are transferred to so-called *breeding ponds*, where the eggs are laid and fertilized. These ponds are always shallow, so that the water in them is thoroughly warmed by the sun. This is essential because Carp will not spawn if the temperature is low. When the young have been moved to other places and the parents have returned to the parent pond, the water in the breeding pond is let out.

In about a week, the small fry are transferred to large *rearing ponds*, where they stay throughout the summer, feeding on small animals, mostly crustaceans (Daphnia, etc.). To increase the food supply, fertilizer is applied to the rearing pond. Sometimes crustaceans are bred in special trenches.

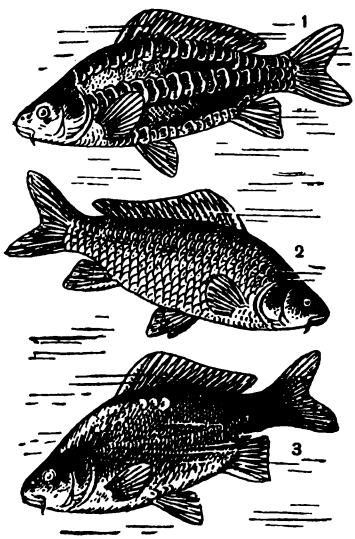


Fig. 88. Carp.
1. Mirror Carp. *2.* Common Carp. *3.* Leather Carp.

The young Carp (known as *this year's brood*) spend the first winter in deep *wintering ponds*, where the water does not freeze to the very bottom. In winter the Carp do not take food and do not grow.

The following spring the one-year-olds are let out into *fattening ponds*, rich in food (various invertebrates, water plants, etc.). Growth is encouraged by adding peas, maize, oil cake, and boiled potatoes to their diet.

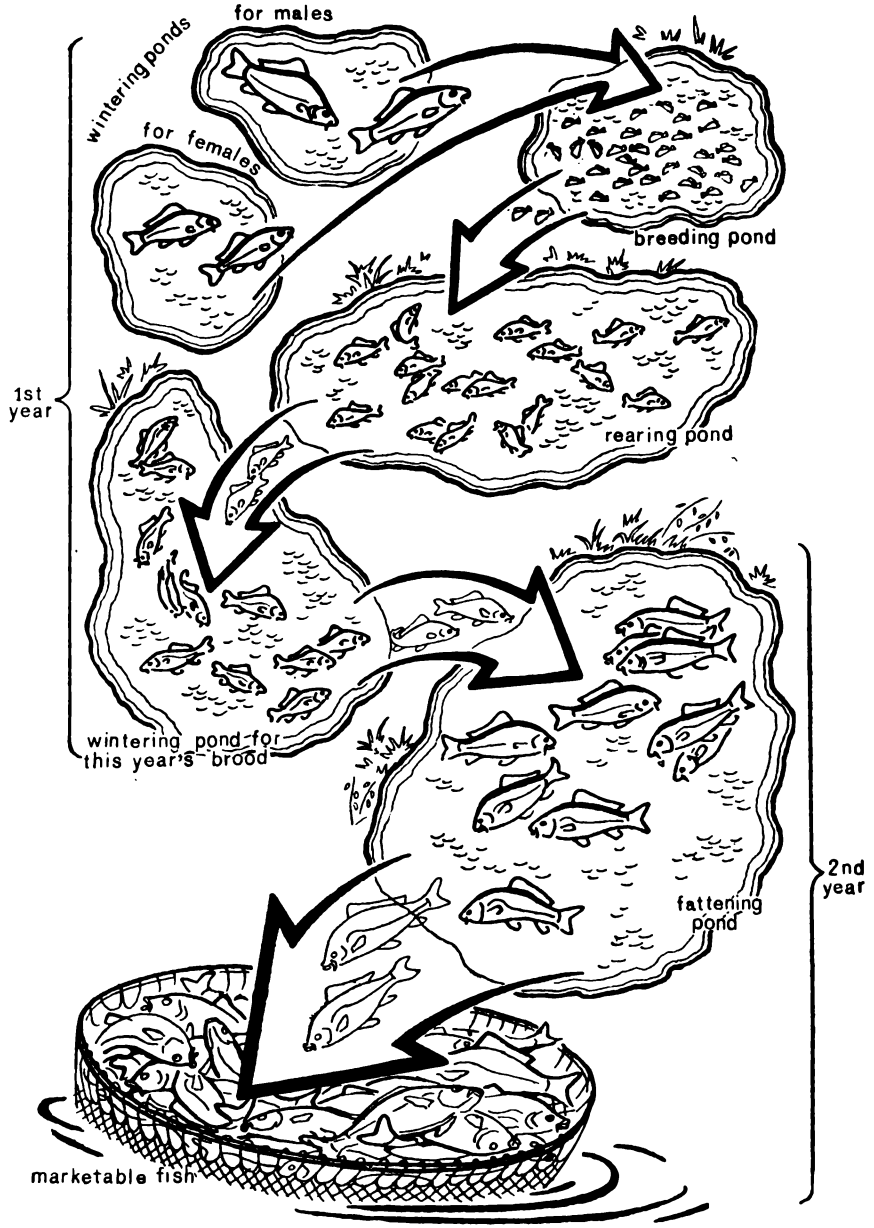


Fig. 89. Diagram of Carp-breeding.

In the fattening ponds the fish grow fast reaching a weight of 600—800 gr. by the end of their second summer, to supply a ready market (*marketable fish*).

Some of the collective farms have fattening ponds where they rear one-year-olds purchased from fishing farms. This is highly profitable: one hectare of water surface can yield up to 20 centners of fish, in the south—even more.

Carp are also bred in rice paddies, where there is plenty of water.

Adaptations. The cultivated varieties of Carp are not found in natural conditions. They have been evolved from one wild ancestor, the *Sazan* (Fig. 80). Man has changed it to suit his own requirements. The flesh of the Carp is of better quality and contains more fat; the Carp grows faster; its behaviour is different: the Sazan is easily frightened and very cautious; the Carp is confident and swims calmly to its feeding place. It does not take long to develop conditioned reflexes not only as regards the place but also the time of taking food.

The difference is due to the influence of more favourable living conditions, created by man. Their improvement is due to the extra diet received in the rearing and fattening ponds, and to the fact that only the finest specimens have been selected for breeding.

The Carp can be regarded as a domesticated animal.

Conclusion. Fish are suited to living in water. They propel themselves through the water with the help of a muscular tail and paired and unpaired fins. Their skin bears slime-covered scales. Most of them possess a swim-bladder. The organs of the lateral line, lacking in land animals, are the best developed. They breathe by means of gills.

Fish belong to the *Vertebrata*, so named because they have an inner skeleton (endoskeleton). The most important part of the skeleton is the backbone (or vertebral column). Fish are the simplest of all the vertebrates: the heart has only two chambers, there is one simple blood circuit, the body temperature is not stable.

Other vertebrates are the Amphibia, the Reptilia, the Birds, and the Mammals.

Questions: 1. What is the difference between the Carp and the Sazan? 2. Why has the nature of the Sazan changed so greatly? 3. Why do we consider the Carp domesticated? 4. How are ponds arranged for the breeding of Carp? 5. Why should breeding ponds be shallow? 6. What are the general characteristics of the fishes as a class?

Chapter Seven

CLASS AMPHIBIA

§ 41. THE EDIBLE FROG. GENERAL CHARACTERISTICS

Habitat. The *Edible Frog* is found during the summer on the banks of rivers and in, or about, ponds (Fig. 90). In the presence of danger it dives into the water with a loud splash. Presently it rises to the surface, and floats with its eyes and nostrils protruding and the remainder of the body immersed. When the danger has passed it emerges from the water again.

In autumn, when the weather gets cold, the frog hibernates in the mud on the bottom of the rivers and ponds.

The Edible Frog has two natural environments. It can live in the water and on land.

External Anatomy. The body is thick, short and without a tail. The head continues rearwards into a trunk, and there are two pairs of limbs.

The limbs correspond to the paired fins of the fish, but each has three separate bones. The front limbs have a *humerus*, a *forearm* and a *palm* with four fingers. The hind limbs have a *femur*, *tibia* and a five-toed *foot*. This modification was specialized for transition onto land, and is typical of all land animals. (Remember the insects.)

When on land, the frog moves by leaping. Its powerful hind legs are ideally adapted for this purpose: the frog straightens them out and throws its body forward. The front legs serve to break the fall after a jump.

The hind limbs are of equal importance for swimming: the feet are *webbed*.

The particular development of the hind legs is the result of endless exercise by numerous generations. (Compare this case of adaptation with the jumping abilities of the locust and the flea.)

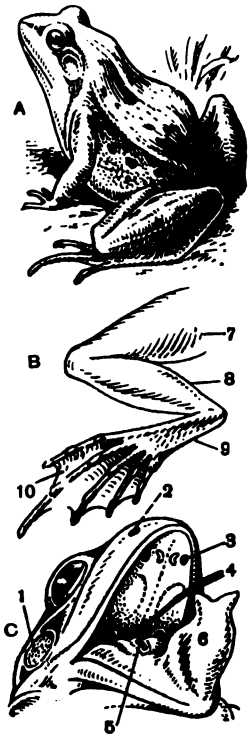
The skin of the frog is bare and slippery: it contains glands which secrete mucous. The scales, typical of the fish, are absent.

The Edible Frog is green to brown on top, with a variable number of black spots. The underside is light. This combination of colours makes it inconspicuous both in the water and in the grass. It does not always help: frogs are eaten in great numbers by grass-snakes, storks, and other animals.

Food. The Edible Frog destroys insects, insect larvae, and slugs. Thick-set and seemingly awkward, it is in fact very agile when hunting. As soon as its prey comes into view, it leaps flipping out its long protrusible tongue at lightning speed. The tongue is wide and covered with sticky mucous secreted by special glands. This makes a good adhesive agent. Unlike the tongue of other vertebrates, the anterior part of the Edible Frog's tongue is attached inside the lower jaw; when it is in use, two posterior pointed tips, normally directed down the throat, are thrust out.

The teeth are poorly developed and lie only along the upper jaw and on the front edge of the palate. In fact, they are hardly visible at all, and can be felt only if you move your finger about the frog's mouth. Frogs swallow their food without masticating it; the only function of the teeth is to hold the prey.

Organs of Sense. Stimulations from the outside world are received by the organs of sense.



On the top of the head are two large, bulging *eyes*. Unlike the fishes, each of the frog's eyes has two *eyelids*—the upper one is almost immovable, but the lower one can be moved easily and its upper part is thin and transparent. Eyelids are possessed by all vertebrates living on land: they protect the outer surface of the eyes.

The frog has a pair of *external nostrils* in front of its eyes, lying above the mouth. Through these air is drawn into the nasal passages which are lined with *olfactory nerve* endings.

Unlike the fishes, the nasal passages lead into the oral cavity. If you open the mouth of a frog, you will notice a pair of *internal nostrils* on the palate. Air passes through these into the oral cavity and the larynx on its way to the lungs.

Fig. 90. Edible Frog.

A. Natural view. *B*. Hind limb. *C*. Head and mouth (open). *1*. Eardrum. *2*. Nostril (external). *3*. Nostril (internal). *4*. Oesophagus (entrance). *5*. Larynx. *6*. Tongue. *7*. Femur. *8*. Tibia. *9*. Foot. *10*. Web.

By protruding only the top of its head (with the eyes and nostrils) out of the water, the frog can breathe and observe the surroundings, without being noticed.

Lying just behind each eye is a round *eardrum*. It is part of the frog's hearing mechanism. Stimulated by sound waves it vibrates; the vibrations are passed through a special little bone to the *internal ear* in the skull, where they affect the endings of the *acoustic nerve*.

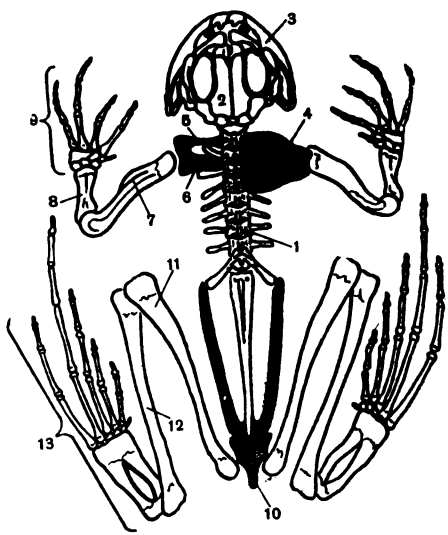
Fig. 91.
Common Frog.

The *Common Frog* is another widespread species (Fig. 91) which is either olive-brown or brown, and can be easily distinguished from the Edible Frog by the dark spot behind the eyes. In summer it is found in the woods.

Questions: 1. In what way does the skin of frogs differ from that of fishes? 2. What is the difference between the limbs of frogs and the paired fins of fishes? 3. What peculiarities in the anatomy of the frog's organs of sight, smell and hearing show that this animal is suited to live on land? 4. Why do we say that the frog is well adapted for living in water?

§ 42. MUSCLES AND SKELETON

Muscles. The frog has a vast set of muscles. The best developed are those which operate the hind limbs and help the animal to jump so expertly. All the muscles are attached to the bones by tendons. The muscles' contractions give rise to bone movements. In some countries (France, China, the USA, etc.) the flesh (muscles) of Edible Frogs is eaten.



Skeleton. The skeleton of the frog in many respects resembles that of the fish, but in other respects is quite different.

Fig. 92. The skeleton of a frog.
1. Vertebral column (backbone). *2*. Cranium (braincase). *3*. Jaws. *4*. Scapula (shoulder blade). *5*. Clavicle (collar bone). *6*. Coracoid. *7*. Humerus. *8*. Forearm. *9*. Hand bones. *10*. Pelvis. *11*. Femur. *12*. Tibia. *13*. Foot bones. (The girdles are painted black.)

The supporting structure is the *vertebral column* (backbone), as in the fish. The backbone is short. It ends with a long bone, known as the *urostyle*, which represents the undeveloped tail vertebrae fused together.

The *ribs* have been lost. In fact, they are present in the embryo but later fuse with the vertebrae.

Unlike the fish, the frog has its *skull* flexibly connected with the first vertebra. The skull is quite large but the braincase (cranium) is not, occupying only the central part. There are no gill-covers.

The structure of the limbs is more complex than in the fish, due to adaptation for land movement. The hind legs consist of the *femur*, the *tibia*, and the many bones of the *foot*. The front legs are divided into the *humerus*, the *forearm* and the fingers of the *palm*.

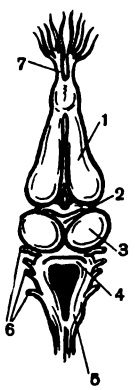
The limbs are attached to the body by means of *girdles*: the *pectoral girdle* in front, which almost encircles the trunk (the halves unite below but are separate above), and the *pelvic (hip) girdle* which is linked with the ischium.

Questions: 1. What do the skeleton of the frog and that of the fish have in common? 2. How do their backbones differ? 3. In what way are the bones of the frog's front and hind legs similar?

§ 43. NERVOUS SYSTEM

Brain and Spinal Cord. The nervous system consists of the *brain*, the *spinal cord* and the *nerves* branching out to all the organs. (Compare it with that of the fish. Recall why the nervous system is considered so important.)

The frog's brain is divided into the same regions as that of the fish (enumerate them in correct order), but they are differently developed.



The *forebrain* of the frog is more highly developed than that of the fish, and more than the other regions. It can be said, therefore, that the structure of the frog's brain is more complex.

On the other hand, the *cerebellum* is much smaller than that of most of the other vertebrates. It is like a narrow band lying in front of the *medulla oblongata* (the afterbrain). This may be owing to its function in coordinating the animal's muscular movements,

Fig. 93. The frog's brain.
1. Forebrain (prosencephalon). *2*. Betweenbrain (diencephalon). *3*. Midbrain (mesence)halon). *4*. Cerebellum. *5*. Afterbrain (medulla oblongata). *6*. Nerves issuing from the afterbrain. *7*. Olfactory nerve.

which are rather limited: it can only leap forward, whereas other animals, for instance, fish, perform complex turns.

If you remove or destroy the brain, a frog does not die at once, but its behaviour changes drastically. If placed on its back it will make no attempt to stand. Put it in an aquarium and it will not swim but will go down to the bottom and stay there, immobile. A frog so treated evidently loses its ability to perform complex, concerted movements. At the same time, it retains its response to stimuli: if you pinch its leg, it will draw it away.

When the brain and spinal cord have been destroyed, the frog becomes totally indifferent to stimuli. Its limbs may be pinched, acid may be poured over it but it will remain immovable. This is quite understandable: when outward stimulation affects the skin, an impulse is sent to the brain and is reflected back from it through the nerves to the locomotary organs (muscles), which produce a response. Since one link in this chain is destroyed, the impulse cannot cover the normal route to reach the muscles.

Behaviour Pattern. The behaviour of the frog, like that of the fish, is largely based on inherited *unconditioned reflexes.* However, it seems possible that it can also learn by experience, i.e., develop *conditioned reflexes.* Food may be given regularly to some frogs on a wooden stick. After a time they will lick the stick even if there is no food on it. Even more remarkable results were achieved when several frogs were fed on hairy, unpalatable caterpillars. The animals snatched them but immediately spat them out. After 4 or 7 "meals" of this kind, the frogs ignored the caterpillars: the sight of them had given rise to a negative, conditioned reflex.

Questions: 1. In what way is the structure of the frog's brain similar to that of the fish? What is the difference? 2. How does the behaviour of the frog change when its brain has been destroyed? 3. Why does the frog cease to react to external stimulation when its brain and spinal cord have been destroyed? 4. What conditioned reflexes can be developed in a frog on the basis of experience?

§ 44. ANATOMY AND FUNCTIONS OF INTERNAL SYSTEMS

Digestive System. When food is taken into the *mouth* and swallowed, it passes through the *pharynx* and the *oesophagus* into the *stomach.* From the stomach it goes to the *small intestine,* which is long, made up of several coils and opens directly into a short, expanded *large intestine.* The digestive system also includes the *liver* and the *pancreas.*

The food is digested gradually as it moves along. Some *digestion* takes place in the stomach, the walls of which are lined with glands

secreting gastric juice. Digestion continues in the small intestine, where the food is acted on by juice secreted by the intestinal walls, bile from the liver, and the pancreatic juice.

The nutritive substances are finally *absorbed* in the numerous blood vessels lining the small intestine.

Undigested food is deposited in the large intestine which expands to form a *cloaca*, to which also lead the genital ducts and ureters. The cloaca provides an opening to the outside of the body. (Where do urinary and genital ducts open in the fish?)

Questions: 1. Describe the digestive system of a frog. 2. Where is the food digested and absorbed?

Respiratory System. The breathing organs of the frog are the lungs. However, they are so poorly developed that much of the respiration (receiving oxygen and giving off carbon dioxide) takes place through the scaleless, slimy skin. (How do the fish breathe?)

The *lungs* are in the form of vascular sacs. The interchange of oxygen for carbon dioxide takes place through the walls of the blood vessels: blood receives oxygen and gives back carbon dioxide, which enters the lungs.

The air enters the *mouth cavity* through the nostrils, passes through the short *larynx* and is forced into the lungs. In the larynx are the *vocal chords*, which vibrate to produce the sound known as "croaking".

Air is forced along by the muscles, which line the floor of the mouth cavity. If you watch a live frog breathing you will notice how the floor of the mouth rises and falls. When it falls the volume of the cavity enlarges and air is brought into the mouth through the nostrils. The floor of the mouth is then raised, the valves in the nostrils close, and the air is driven into the lungs, dilating them. Apparently, this system makes breathing possible only if the mouth is shut. (Compare this method with the way fish breathe.)

Oxygen can enter the blood through the wet *skin* not only from the air but also when the animal is surrounded with water. Therefore, the frog can remain submerged for a long time, especially if the water is cold. However, skin breathing stops as soon as the skin becomes dry. When this happens, the frog dies for respiration through the lungs is insufficient.

Questions: 1. What is the difference between the breathing systems of the frog and the fish? 2. Why does the frog die when its skin becomes dry?

Circulatory System. Since the frog is a breathing vertebrate having lungs, its vascular system is more complex than that of the fish.

The *heart* consists of *three*, not two, *chambers* (a *ventricle* and two *auricles*, the left and the right). There are two blood circuits, as distinct from the fishes which have one (Fig. 94).

The *systematic* (*greater*) *circuit* carries the blood from the ventricle to all the organs along the *arteries*. In the *capillaries*, the blood gives off oxygen (received in the lungs and through the skin) and the nutritive substances (received from the intestine), takes in carbon dioxide, and returns through the *veins* to the *right* auricle.

The other, *pulmonary* (*lesser*) *circuit* passes from the ventricle to the lungs and the skin, where it is oxygenated, and returns to the *left* auricle.

A study of the circulation reveals that all the blood entering the frog's heart is not the same; the blood flowing into the left auricle from the lungs is rich in oxygen, while that flowing into the right auricle from all the other organs contains considerable amounts of carbon dioxide. On reaching the ventricle from both auricles, the two streams are mixed together. The ventricle then contracts, and the mixed blood, containing oxygen and carbon dioxide, is passed on to all the parts of the animal's body.

Question: Why is the circulatory system of the frog more complex than that of the fish?

Excretory System. The excretory system of the frog is made up of a pair of flattened, elongated *kidneys* lying on each side of the backbone. Urinary ducts (may also be called ureters) carry the urine, which is continually being excreted by the kidneys, to the urinary bladder, where it accumulates.

Metabolism. The functioning of the organs in the body of the frog, which results in nutritive material being built up into living matter or protoplasm being broken down into simpler substances, is called metabolism. This uninterrupted process takes place in all animals.

The process of metabolism is slow, as in the fishes, and little heat is produced. The temperature of the frog's body varies depending on its environment. When the frosts come the

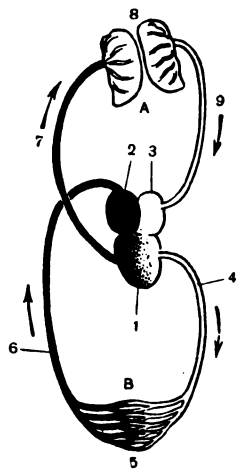


Fig. 94. A diagram of the circulatory system of the frog.

(*A*) The pulmonary circuit; (*B*) The systematic circuit *1*. Ventricle. *2*. Right auricle. *3*. Left auricle. *4*. Artery supplying blood to all the tissues. *5*. Capillaries. *6*. Vein carrying blood to the right auricle. *7*. Artery taking blood to the lungs. *8*. Lungs. *9*. Vein picking up blood in the lungs and running to the left auricle. (The skin circulatory system is not visible.)

metabolic rates go down, and the frog hibernates to escape the cold. During hibernation no food is taken, breathing is almost imperceptible, and body temperature falls to just a few degrees above zero.

Question: In what way does its metabolism change when the frog hibernates?

§ 45. REPRODUCTION AND LIFE-CYCLE

Reproduction. During warm spring evenings loud croaking may be heard in ponds and rivulets. These "concerts" are put on by frogs which have awakened from their winter hibernation. The sounds can be produced only by males. When they croak, Edible Frogs inflate two large sacs on both sides of the head to intensify the volume of the sound.

The "concert" period coincides with the breeding season. Females lay *eggs* in the water. The eggs are very similar to those of fish. The males discharge fluid containing *sperm*. Fertilization takes place in the water. The gelatinous envelopes surrounding the eggs swell, causing them to adhere to each other, and clusters of jelly are formed.

Development. Fertilized eggs divide once, twice, three times, and so on. Gradually, *multicelled embryos* coated with jelly develop.

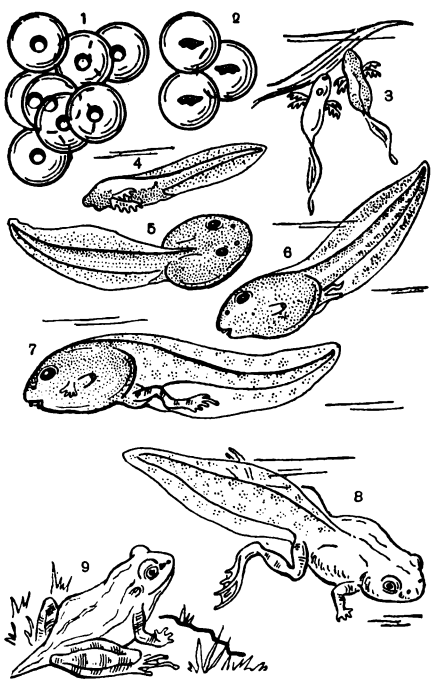


Fig. 95. Frog's life-cycle.
1. Eggs. *2*. Embryos in envelopes. *3, 4*. Tadpoles with external gills. *5*. Tadpole with internal gills. *6, 7, 8*. Tadpoles with limbs. *9*. A young frog with a remnant of a tail.

In about 8—10 days (depending on the water temperature) little *tadpoles* hatch (Fig. 95). They bear no resemblance whatever to adult frogs, but are like young fishes, having the same bodily form and a long tail, and fluffy *external gills*, which are used to take oxygen from the water to the blood.

During the first few days the tadpole remains attached to a water plant by means of a *sucker* which is in the lower

part of its head. It has no mouth and feeds on what remains of the nutrient substances from the egg.

In a few days a small *mouth* bordered with horny *jaws* develops, and the tadpole begins to feed independently by scraping algae, bacteria, and decaying organic matter from the leaves of water plants.

Presently, the fluffy external gills are lost, and the tadpole begins to breathe by means of *gill slits* and *internal gills*, like a fish. In this period it is very much like a small fish not only in appearance but also in its internal anatomy. It possesses gills, a bi-chambered heart, one blood circuit, and *lateral line organs*. It also has a *notochord*, like some of the fishes. If its origin were unknown, the tadpole could easily be mistaken for a small fish. This stage continues for about a month.

After this, the tadpole begins to develop *limbs*: hind legs first and front ones afterwards. Occasionally, it comes to the surface to breathe fresh air through its *lungs*. With the lungs comes the second blood circuit and another chamber in the heart. The tail shortens. The tadpole changes into a small frog.

The young frog hops away from the water. Its food is no longer vegetarian; it is strictly carnivorous. Only the remnant of the tail is still there to remind one of its tadpole past. However, the tail continues to become shorter and shorter, till it disappears altogether.

It takes three or four years for the frog to mature and become capable of reproduction.

Questions: 1. What is there in common between the reproduction of frogs and fishes? 2. Why do we say a tadpole is like a fish?

§ 46. TOADS AND NEWTS

Among the many different kinds of commonly-found Amphibia are the Toads and the Newts.

Toad. Toads spend most of their lives in vegetable or flower gardens, hiding in quiet moist places (in holes or under buildings) during the day and coming out on hunting expeditions at dusk, when the air becomes humid. Toads can be said to have nocturnal habits.

Outwardly, they resemble frogs but are easy to distinguish from them (Fig. 96). The frogs have a smooth skin, while that of the toads is warty, secretes intensely bitter slime—quite harmless to

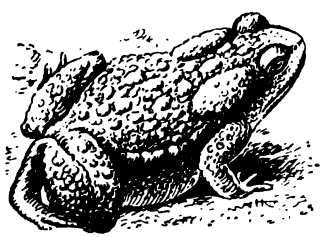


Fig. 96. Toad.

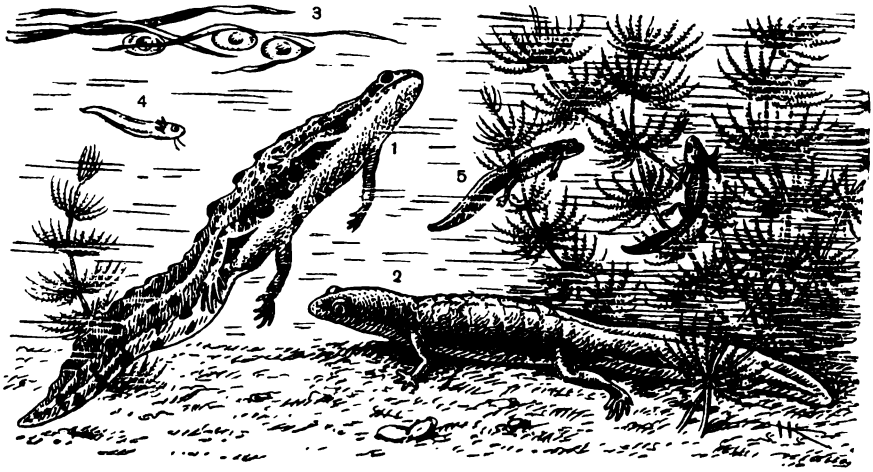


Fig. 97. Newts.
1. Male. *2.* Female. *3.* Eggs. *4* and *5.* Larvae.

human skin but irritating to the delicate mucosa of the eyes and lips.

The toad sometimes crawls, and at others hops. Although its hind legs are longer than its fore legs, they are not as well developed as those of the leaping frog.

The peculiarities of its anatomy are explained by its specific way of life. The toad feeds on slugs, earthworms, non-flying insects and their larvae. Its method of locomotion is different. It does not have to hop as high as the frog to catch flying prey. It is thick-set and rather clumsy, and the hind legs are not powerful.

The excretion of the bitter slime serves as a protection from the enemies. Birds, whose diet includes frogs (for instance, the stork), take care to avoid toads.

Toads live on land, but lay their eggs in water, where they gather during the spring months. Long strings of slime containing innumerable eggs are festooned in ponds, rivulets and even muddy pools. Soon after fertilization, tadpoles drop into the water, where they continue their development until they become real baby toads in summer, and leave the water.

Toads are useful because they destroy insect pests, which become active in the evening and at night, and are therefore out of birds' reach. Stories that toads are the cause of hand warts are quite untrue.

Newt. Externally the Newt is easily recognized from the frog and the toad (Fig. 97).

It has an elongated body which ends in a long *tail.* The tail is flattened on the sides and bordered with a *web for swimming.* The

limbs are short and serve to push the animal from place to place on the ground.

In spring and early summer newts keep to ponds overgrown with water plants. They breathe with their lungs, rising to the surface of the water every 2 or 3 minutes to gulp in air. In the second half of summer newts leave the water and find shelter in moss or under tree roots, where they remain concealed throughout the winter. As soon as spring sets in, they return to the pond.

Their diet consists of animal matter—larvae, insects, worms.

At breeding time, newts lay eggs, attaching each one to water plants. The larvae have external gills and are very much like tadpoles.

At this time the males develop a skin *crest*. Their colour pattern becomes more conspicuous.

Questions: 1. What is the difference between a toad and a frog? 2. How can you distinguish a newt from a frog? 3. Where does the newt spend most of its life? 4. How does the newt reproduce and develop?

§ 47. GENERAL CHARACTERISTICS AND PAST HISTORY

General Characteristics. Frogs, toads and newts, which belong to the *Class Amphibia*, live both in the water and on land. They breed and develop in the water, have jointed limbs, and are adapted for moving on solid surface.

They breathe by means of lungs and through their moist slimy skins, have a three-chambered heart and two blood circuits. The organs are supplied with mixed blood. The body temperature is unstable.

They are divided into *tail-less* (frogs, toads) and *tailed* forms (newts).

The vast majority of known species, about 2,000, live in tropical countries where the climate is mild and damp.

Past History. All amphibians reproduce in the same way as frogs. Their eggs, which they lay in the water, hatch into tadpoles, which develop into adult animals.

The fact that both classes lay eggs in the water and that tadpoles greatly resemble fish (both in appearance and internal anatomy) is not by chance. Scientists have proved that ancient amphibians descended from fish.

Among the fossil fishes are the *Crossopterygian* fishes

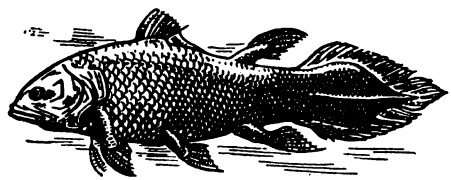


Fig. 98. Crossopterygian Fish.

which may be regarded as the ancestors of the amphibians (Fig. 98). In structure and habits they differed from other fishes, having paired fins adapted for crawling about the sea bottom. The skeleton of the paired fins greatly resembled the limb bones of the first amphibians. The air-bladder, which may be referred to as a *lung*, was capable of breathing air. If there was an insufficient supply of oxygen in the water the fishes could gulp in fresh air.

Until a short while ago, the Crossopterygian fishes were considered extinct. Recently, however, a few of them were caught unexpectedly in the Indian Ocean off the coast of Africa.

Apparently, the transition of the Crossopterygian fishes from the water to land took place in the following way.

There must have been a time when the only vertebrates on the Earth were fishes. When the climate became dry, in some of the places where they lived the water became shallow or dried up. In order to survive they used their ability to take in air, came onto the land and by means of their paired fins moved to other pools.

Some found food near the water's edge, and stayed there. This probably continued for many generations. Gradually, they became suited to moving on land and breathing air. Their paired fins modified into limbs, the air-bladder into real lungs. The development of the lungs led to the formation of another blood circuit. The heart acquired a third chamber.

The transformation took a long time but that is why we say that fish are the ancestors of the amphibians, animals which spend most of their life on land, but are hatched, as a rule, in the water.

Questions: 1. How can you explain the presence of common features in the tadpole and the fish? 2. What peculiarities did the ancient Crossopterygian fishes have? 3. Why do we say that the amphibians originated from fishes?

CLASS REPTILIA

§ 48. THE SAND LIZARD

Habitat. On hot summer days the *Sand Lizard* (Fig. 99), a land animal, may be found on the edges of woods, on dry sunlit clearings and hillocks. When disturbed, it darts off at lightning speed to hide in the rocks or grass.

The lizard differs from the amphibians in that it is strictly confined to land, having special structural modifications to make it fit for such an existence.

The lizard has an elongated body, two pairs of short limbs, and a fairly long tail. Since the limbs are not strong enough to support the body, the belly and the tail rest on the ground. The animal wriggles from place to place. The lizard uses its long fingers and toes (five on each limb), armed with sharp claws, to climb onto rocks and stumps.

The *skin*, which is dry and usually covered with horny scales of various forms and sizes, is totally devoid of glands. (Remember the fish and the amphibians.) A skin like this affords excellent protection by preventing the body moisture from evaporating when the air is dry. At the same time, oxygen cannot penetrate it as it does the slimy skin of the amphibians. As the lizard does not take in fresh air through the skin, like the frog, its *lungs* have to be much better developed.

The outer horny layer of the skin is shed in flakes several times during one summer. This takes place as soon as a new skin has grown underneath.

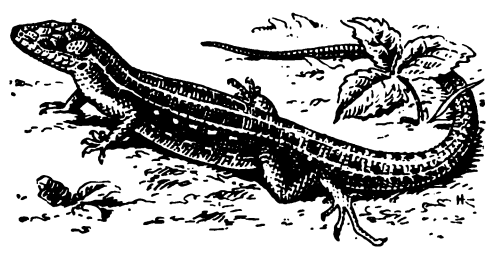


Fig. 99. Sand Lizard.

Fig. 100. Lizard eggs.

The colour of the scales usually harmonizes with the surroundings, the greyish-brown of the females and the greenish of the males being inconspicuous in the grass. In spring the males take on a brilliant green hue.

The lizard is most active during the heat of the day and rapidly becomes sluggish in a cool temperature. In the evening it crawls under a rock or conceals itself in a hole, where it also hibernates during the long winter period, blocking the entrance with moss. The temperature of the body is unstable.

Nutrition. Lizards eat insects, spiders and worms. The lizard seizes its prey in its large mouth, which is armed with identical teeth, used for holding the prey. Its fluid requirements are satisfied by licking up dew-drops and absorbing the moisture contained in the bodies of its prey.

The fact that the head is flexibly united to the trunk by a *neck* facilitates the catching of food. The tongue, which is long and forked at the tip, is not used to catch prey but primarily as an *organ of touch*.

Lizards destroy insect pests and should be protected.

Autotomy. The lizard greatly depends on its agility to provide itself with food and escape from its enemies.

In the presence of danger, the lizard rapidly hides itself in safety. If it is caught by the tail, the tail comes off. This means of protection is known as *autotomy* (*self-mutilation*).

By sacrificing part of the tail, the lizard may save its life. The act is instinctive. Autotomy is an example of unconditioned reflex. The touch of the enemy gives rise to an impulse which is passed by the nerves from the tail to the spinal cord from which it is relayed to the tail muscles. These contract sharply, and part of the tail falls off. Later on the lizard grows another tail (remember the Hydra), but the new tail is usually shorter than the original. The process is known as regeneration.

Reproduction and Development. The process of breeding differs from that of the animals which lay their eggs in the water.

In the fishes and amphibians, fertilization takes place in the water: agile sperms swim up to the ova and the two cells merge. This is impossible on land. In the case of lizards, the male introduces the sperm-containing fluid into the female's cloaca. Fertilization therefore takes place inside the animal (*internal fertilization*). This feature is common to all animals living on solid ground (insects, birds, mammals).

Lizard eggs differ from those of the fishes and amphibians (Fig. 100). Small numbers (5-10) of relatively large eggs, the size of a sparrow's and extremely yolky, are laid. They are enclosed in a white leathery covering which prevents them drying out, an important adaptation to development on land.

The eggs are deposited in the soil and contain embryos whose growth began within the mother's body. In the new, warm situation the process continues until they hatch.

The enormous quantity of yolk helps the baby lizard to be born much more developed than the young fish or amphibians. Baby lizards emerge well adapted for independent life: they are able to procure food and they look exactly like adults, except that they are much smaller.

Questions: 1. What modifications show that the lizard is adapted to living on land? 2. How does the lizard reproduce and develop? 3. Why do we say that lizards are anatomically more developed than amphibians? 4. What is there in common between the newt and the lizard? In what way do they differ?

§ 49. SNAKES

Snakes are also reptiles. The commonest in the Soviet Union is the Grass Snake and the poisonous Adder.

Grass Snake. The *Grass Snake* lives near ponds and rivers, where it finds its main food: frogs, tadpoles, and fish. It can be easily distinguished from the Adder by two *orange-yellow* (sometimes whitish) *spots* which flank both sides of its head.

The Grass Snake is non-poisonous. When caught, it does not bite, and can therefore be held in your hands, if you are quite sure it is a Grass Snake and not a poisonous one.

Like other snakes, it has no limbs. However, it enjoys great freedom of movement on land and swims expertly, wriggling its long (up to 1 m.) body as it does. The absence of limbs enables the animal to crawl through narrow apertures in heaps of brushwood and rocks.

In some of the snakes (*Boa Constrictors*) rudimentary hind limbs are present under the skin. This leaves no doubt that the ancestors of the modern snakes were four-footed, like all other vertebrates.

In the Grass Snake the upper layer of skin is horny. This is common to all reptiles. The scales on the back and sides are small, but on the belly they are broad and grow transversally. When the Grass Snake crawls, the belly scales make firm contact with the uneven ground.

Unlike the skin of the lizard, the Grass Snake's skin does not flake off, but is shed in one piece. The Grass Snake first tears it about the

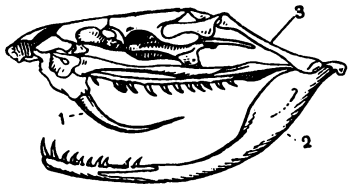


Fig. 101. The skull of an Adder. *1*. Fang. *2*. Lower jaw. *3*. Bones attaching the lower jaw to the skull.

lips (by rubbing against the ground or stones), and then crawling through a narrow aperture slowly slips out of it, pulling it off like a stocking—inside out.

The Grass Snake is usually of a dark colour (from brownish to black) above, and almost invisible on the ground; the belly is light yellow.

Food (mostly frogs) is sought on land and in the water. The slimy prey is held fast with backward-curved *teeth*, and swallowed alive, without mastication, although the frog is, of course, much larger than the Grass Snake's head. This is possible owing to a special modification of the mouth-parts. The lower jaw is loosely attached to the skull by means of a slender bone, the right and left parts being connected by a ligament which allows them to spread. Because of this the Grass Snake is able to open its mouth very wide forming a large passage into the gullet, which is also capable of expanding.

It takes a considerable time for the large prey to be digested. In captivity (Young Naturalists' Corner) Grass Snakes are usually fed twice a month.

When searching for food the Grass Snake projects its long tongue, forked at the tip, which is really used as a *sensory organ*. People who do not know the anatomy of the Grass Snake often wrongly refer to it as a fang.

The *eyes* are covered with connate transparent *eyelids*, which protect them when the Grass Snake crawls through the grass, and are shed together with the rest of the horny skin.

In summer the female produces about 20 large oval eggs, enclosed in a white leathery skin, like parchment. They are deposited in a warm situation: decaying timber, garbage or manure. Soon the little Grass Snakes hatch out. When winter comes, the hibernation period begins.

Questions: 1. What can you say about the general characteristics of snakes? 2. How can you explain the fact that the slender Grass Snake is able to swallow a large frog?

Adder. Unlike the harmless Grass Snake, the grey, brownish, and black *Adder* is *poisonous*. It can be distinguished from the Grass Snake not only by the absence of yellow spots on its head, but also by a dark *zigzag stripe* up the middle of the back. The stripe continues on the head, forming the letter "*x*".

Most of the day is spent idly, basking in the sun or hiding in the grass and rocks. Mice and other small animals are hunted at night.

The prey is poisoned by venom injected through the *fangs*, which lie in the upper jaw, one on each side, and are clearly visible when the mouth is opened wide (Fig. 101). Each fang has a thin hollow tube, with an opening at the tip, and connected with the *poison glands* on both sides of the head. This is why the head is *broader* at its posterior end and is distinct from the body. This feature helps to distinguish the Adder from the Grass Snake. When the mouth is shut the sharp fangs point down the throat and lie against the roof of the mouth. When the mouth is opened, they protrude at right angles to the roof.

Small animals bitten by Adders die in a few seconds. If it is disturbed by a bigger mammal, even a human being, the Adder may attack. The effect of the poison is not always the same: Adders are sometimes eaten by certain animals, for instance, pigs and hedgehogs, quite safely. The harm to a person depends on the amount of poison injected into the wound and the place of the bite (the nearer to the head, the more dangerous it is). Sometimes an Adder's bite proves fatal.

If you are bitten by an Adder, seek immediate medical help. In the meantime: a) squeeze out the blood in order to remove some of the poison; b) cleanse the wound with a 1 per cent solution of potassium permanganate—an anti-poison destroying the effects of the bite.

Eggs are formed within the body of the female and begin to develop before being laid. Adders are born alive from eggs. This allows the snake to be widely distributed in the northern areas where there is a moist, moderate climate, a short summer, and rather unfavourable conditions for egg development. From its method of reproduction the Adder can be classified as ovoviviparous.

Questions: 1. How can the Adder be distinguished from the Grass Snake? 2. How does the Adder kill its prey? 3. What measures should be taken against an Adder bite before the arrival of a doctor?

§ 50. CROCODILES AND TURTLES

Crocodile. The crocodiles, another group of reptiles, spend the greater part of their lives in water. The *Nile Crocodile* (Fig. 102), which inhabits the rivers and lakes of tropical Africa, is one of these.

This animal grows 6—8 metres long and resembles a lizard in appearance. It has a long body terminating in an equally long tail and two pairs of short legs. The tail is not round, however, but com-

pressed on either side. With the hind limbs, which have membranes between the toes, it forms an efficient swimming organ. On land, crocodiles are rather clumsy.

Other modifications that make for the ease of living in water are present in a number of its organs. The eyes and nostrils lie on the dorsal side of the head and protrude somewhat. By keeping close to the surface and exhibiting part of its head, the crocodile can breathe and observe the surroundings without having to show the rest of its body. (What other animal has an identical adaptation?) When it sinks, the nose and ears are closed by valves.

The crocodile eats only flesh. It hunts fish and birds, and is known to attack mammals as they come to the banks of rivers to drink. It drags the larger animals into the water and tears them apart.

The mouth is large and abundantly supplied with large, very sharp teeth. Those in the upper jaw fit into sockets in the lower jaw, and cut through flesh like scissors. Smaller animals and birds are swallowed in one piece. Crocodiles have a bad reputation for attacking people. Therefore it is dangerous to bathe in rivers in which they live.

Reproduction takes place on land. The female buries her several dozens of eggs in the sand on river banks. The eggs are white, oval, as large as those of a goose, and enclosed in a hard limy shell. Unlike the eggs of lizards and snakes, they contain not only yolk but also albumen. Embryos are incubated by the heat of the sun. The eggs hatch into little crocodiles, 20—25 cm. long, which immediately enter the water.

The crocodile is a typical representative of its class. Its body is covered

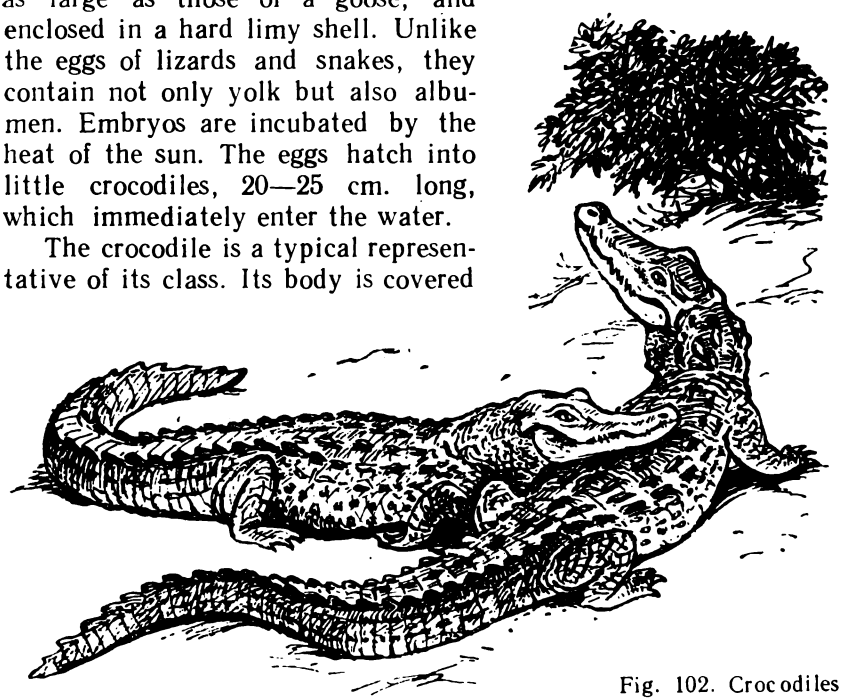


Fig. 102. Crocodiles.

with a horny armour (with bony shields on the back); it breathes air; it reproduces by laying eggs. This makes it obvious that its ancestors lived on land and were subsequently re-adapted to an aquatic existence.

Apart from Africa, crocodiles are found in tropical countries of Asia and America.

Questions: 1. Why can we say the crocodile is suited to live in water? 2. Why is it impossible to classify the crocodile as an amphibian? 3. Why do we say that the ancestors of the crocodile lived on land?

Turtles. The *Central Asian Turtle* is a familiar object in the south-east of the USSR (Fig. 103).

It is so odd-looking that it can easily be distinguished from all other animals. The body is short and broad, and enclosed in a bony shell. The upper part of the shell (carapace) is vaulted, the ventral part (plastron) is flat. The shell is covered with horny plates. The two portions of the shell are united at the sides by a solid "bridge", making a heavy armour and a first-rate means of protection. It is impossible to pull the animal out of its shell since the ribs and vertebrae of the back are solidly joined to the upper part of the shell (Fig. 104). Only the head, the short limbs and the tail are extended through the openings.

Because of its long and easily movable neck, the animal is able to protrude its head some distance to investigate the outside world.

The turtle moves slowly and awkwardly, dragging its heavy body along. (There is even a saying in Russian about it which corresponds to the English "a snail's pace".) The limbs are thick and armed with sharp claws, used by the animal for digging holes and burrowing into sand.

The turtle is a vegetarian, and does some harm to crops. It has no teeth, but the jaws are equipped with horny cutting margins making it possible to bite off bits of vegetation with great ease.

During the hot summer months, when plants dry out, food becomes short. In these unfavourable conditions, turtles bury themselves in holes and hibernate till the heavy autumn rains come and plant life flourishes with renewed vigour. The turtles then wake up, find plenty of food, and become active again. When the frosts set in, they enter another period of hibernation, which lasts till spring.

In the deserts of Turkmenia, where vegetation is scarce in autumn, turtles hibernate right through the summer

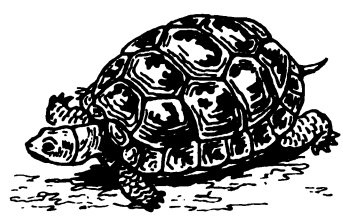


Fig. 103. Central Asian Turtle.

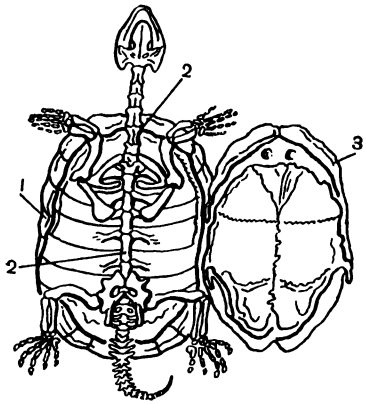


Fig. 104. The skeleton of a turtle.
1. The upper part of the shell (carapace). *2*. The backbone. *3*. The ventral part of the shell (plastron).

and winter without a break. The animals are almost lifeless for 8—9 months. This is a useful adaptation enabling them to exist in the desert where fresh vegetation is available only in spring.

In spring the female lays 5—6 eggs in a hole in the sand. The eggs are large, protected by a white limy shell, and contain two nutritive substances—yolk and albumen. Warmed by the sun, the embryos develop and little turtles hatch out.

The eggs, which are not inferior to hen eggs, find a ready market. The flesh of the turtle is not only edible but delicious.

Another species distributed in the southern areas of the Soviet Union is the *Bog-turtle*. It lives in small rivulets and ponds, keeps to a diet of invertebrates and water plants, and differs from its Central Asian relative in having a more flattened carapace.

Marine Turtles inhabit seas and oceans, and sometimes reach enormous dimensions.

All groups breed on land.

· **Questions:** 1. Why is the shell armour important for the turtle? 2. Why is it impossible to take the turtle's body from its shell? 3. How can Central Asian turtles exist in a desert?

General Characteristics of the Class. The Class Reptilia comprises lizards, snakes, turtles and crocodiles. All groups are adapted to a terrestrial existence. In the crocodiles and some turtles modifications to aquatic existence were developed for the second time because their ancestors had already lived on solid ground.

The skin of the reptiles bears a horny layer, which enables them to withstand the effects of heat and dryness. They can breathe only by means of their lungs, which are better developed than in the amphibians. The heart shows notable advances, having three chambers. But the partition in the ventricle is incomplete. The brain is also more complex.

Reproduction of all the groups (including water-living ones) takes place on land. All lay eggs that are enclosed in solid shells or tough skins.

The surviving members of the class number nearly 4,500 species.

The Rise of Animal Life. At present reptiles are not so widely distributed as other vertebrates—fishes, birds, or mammals. They are seldom found in cold regions, are not numerous in temperate climates. They flourish in tropical conditions. However, there was a time, long, long ago, when this group dominated animal life, both in variety and distribution.

Some of the fossilized specimens which have been discovered and analysed prove that the animal world has been developing continually. Lots of animals have vanished from the face of the Earth, some becoming extinct and others more highly developed. Similar transformations are known to have occurred in plants.

The most important stages in the development of life on Earth are measured in separate eras: the most ancient era; the Paleozoic Era; the Mesozoic Era; and the Cenozoic Era (the most recent).

The *most ancient era* continued for the longest period, almost 1,500 million years. The *Paleozoic Era* lasted 325 million years; the *Mesozoic Era*—120 million years; the *Cenozoic Era* began 71 million years ago. In determining time by this method, we conclude that life has existed on our planet for about 2,000 million years.

Early Reptiles. Fossil remains of early vertebrates have been discovered in strata dating back to the Paleozoic Era. Fishes appeared first, and were followed by amphibians.

Towards the close of the Paleozoic Era, the climate of many regions in the world, which was hot and damp, must have become drier. Those conditions proved unfavourable to the amphibians with their scaleless,moist skins.Some adapted themselves by developing a horny skin, and continued living on land.

The new environment gave rise to a chain of other adaptations: the lungs developed until they were able to meet fully the oxygen requirements of the organism; there were notable advances in the brain; the animals learnt to reproduce in the absence of water by laying large eggs enclosed in hard shells or

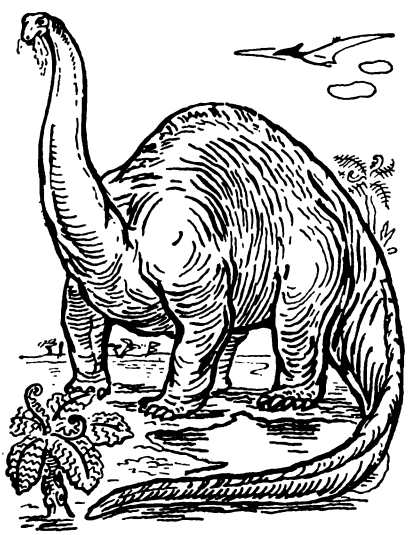


Fig. 105. Monster Reptile (Brontosaurus).

Fig. 106. Theriodont.

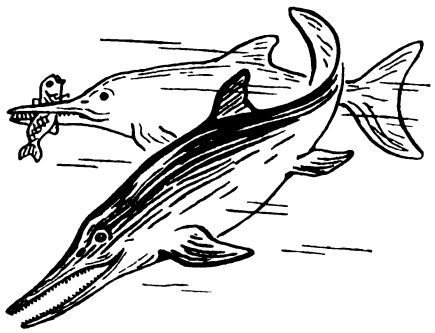


Fig. 107. Fish-like Reptile (Ichthyosaur).

Fig. 108. Flying Reptile (Pterodactyl).

tough skins. Thus the early amphibians developed into early reptiles (stem reptiles).

Variety of Form. The reptiles reached their peak in the Mesozoic Era, when the birds and mammals were few and unimportant. That is why the era is called the *Age of Reptiles.*

A great number of skeletons of extinct reptiles are being discovered in the Mesozoic strata. Some bear a distinct resemblance to modern turtles, lizards, snakes, and crocodiles. Others look very different.

Among the walking land vertebrates were the *Dinosauria* (monster reptiles). Some were really huge. The Brontosaurus, for instance, attained a length of 30 metres (Fig. 105).

The carnivorous *Theriodontia* (Fig. 106) were notable because their teeth were differentiated into incisors, canines, and cheekteeth, whereas the other reptiles had only a row of sharp pegs.

The seas swarmed with *Ichthyosauria* (fish-like reptiles), the forerunners of the modern fishes (Fig. 107).

Bones and imprints also indicate the existence in those times of *Pterodactyls*, flying reptiles which had leathery, membranous wings (Fig. 108).

Extinction. Why did these reptiles become extinct, giving way to others?

One of the factors was the change in the climate which grew much cooler at the close of the Mesozoic Era. The new conditions were most unfavourable for the reptiles, whose body temperature had never been stable. Many proved unable to withstand the change, and died.

Another important factor was the development in the Mesozoic Era of the birds and mammals. Unlike their ancestors, the early reptiles, both groups were warm-blooded, i.e., were able to maintain their bodies at a constant temperature, and had a more developed brain. In the Cenozoic Era, they attained prevailing prominence, and almost completely ousted the reptiles. Lizards, snakes, turtles and crocodiles are only scanty remnants of a group of animals which was most widespread ages ago.

Questions: 1. What eras in the history of life on Earth do you know? How long did they last? 2. Why is the Mesozoic Era called the Age of Reptiles? 3. What kinds of reptiles existed in those times? 4. How can you explain the dying out of the reptiles?

Chapter Nine

CLASS BIRDS

§ 52. ROOKS

Habitat. To understand the natural history and anatomy of birds it is sufficient to study one species, for instance the *Rook.*

In the temperate zone of the Soviet Union, Rooks return in March when the snow is just beginning to melt. They come with the first days of spring, remain throughout the summer, and then migrate either to the warmer regions of the country, or to Southern Europe and North Africa for the winter.

Rooks often nest in the tree-tops in groves and parks, flying to nearby fields in search of food. Their loud cawing is particularly noticeable in spring when they are building their nests and rearing their young, and again in autumn when they hold their noisy councils in the evening, upon return from the fields.

Rooks are omnivorous, consuming vegetation, May-beetles, grubs, and earthworms. At ploughing time great flocks of them dig insects and larvae out of the upturned soil.

They also eat seeds and the young, tender shoots of different plants, including grain, causing a certain amount of damage to agriculture. In spring they become a great nuisance, devouring maize shoots and sprouting seeds.

From this it can be seen that Rooks are both useful and harmful birds.

External Features. From its external appearance it can be seen that the Rook, like most other birds, possesses the power of flight.

Its body is clothed in feathers, which assist flight and, being poor conductors of heat, help to keep the bird warm. The feathers are of two kinds: *contour feathers*, which form the outer layer, and beneath them *down feathers* (Fig. 109).

The fore limbs have been modified into *wings*. The broad, solid body is rounded and streamlined and well adapted to flight.

The large contour feathers of flight are on the wings. They are known as *oar feathers* (or *remiges*) (Fig. 110).

The body is sustained in the air and pushed forward by rapid down strokes of the widespread wings. The broad tail, formed of *rectrices*, which are also contour feathers, acts as a rudder.

The Rook has two well-developed legs. Each foot has four toes armed with horny claws. The first three are directed forwards, the fourth backwards. This arrangement, as well as providing excellent support for the bird's weight, enables it to perch on the limbs of trees.

The *head* is joined to the trunk by a long *neck*, which offers little resistance to the air when the bird is in flight. The front portion of the head extends to form a long beak covered with a thick horny layer. The beak is used to pick up food from the ground and also when building the nest. In old Rooks the beak is bare around its base revealing whitish skin.

The eyes are at the sides of the head and have three movable eyelids: two *upper lids* and one thin, transparent lower lid, or *nictitating membrane*, which covers the whole eye protecting it from excessively bright light. The eyes are extremely well developed.

The *nostrils* lie at the base of the beak.

The *ear openings*, to the rear of the eyes, are covered with feathers and are not readily seen.

Feathers. A contour feather consists of a *shaft* and a *vane*, which form a light single surface for striking the air. The lower part of the shaft is called a *quill*. In olden times goose quills were sharpened and used for writing.

Down feathers differ from the contour feathers in that the vanes do not form a single surface. They serve as insulation, keeping the body at a constant temperature.

The vanes of the contour feathers are so constructed that they overlap like scales, covering the down feathers and preventing cold air from reaching the body even when the bird is in swift flight.

Fig. 109. Feathers.
1. Contour feather.
2. Down feather.
3. Down.

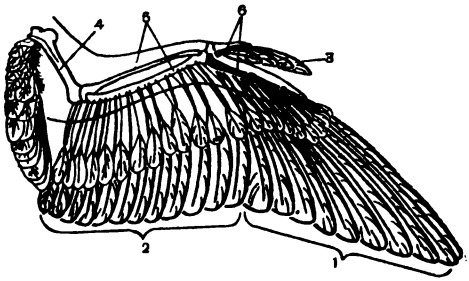


Fig. 110. A bird's wing.
1 and *2*. Oar feathers. *3*. Bastard wing. *4*. Humerus (shoulder bone). *5*. Radius and ulna. *6*. Hand bones (blackened).

Feathers are made of horn. When burnt they give off a characteristic odour.

The lower parts of the legs (the toes and tarso-metatarsus) are covered with overlapping horny scales. The jaws are also horny, which shows again that in their external anatomy birds resemble reptiles.

Like reptiles, birds moult : the feathers fall out and are replaced by new ones.

Questions: 1. Where do Rooks build their nests and what do they eat? 2. How do birds move from place to place? 3. Why is the neck long? 4. What is the difference between a contour feather and a down feather? 5. Why do we say that the coverings of birds resemble those of reptiles? 6. What is understood by "power of flight"?

§ 53. MUSCLES AND SKELETON

Muscular Arrangement. The Rook and the other birds have well-developed muscles. The great *pectoral muscles*, which pull the wings downwards and raise them again, are particularly powerful. They are the organs of flight. The *leg* and *neck muscles* are also strong. (Where do you find most meat when eating chicken or game?)

The legs are equipped with special muscles. The long leg tendons are attached to the underside of the toes. When a Rook perches, the tendons tighten and the toes bend round the branch. The bird then does not fall off even when it is asleep.

Questions: 1. What muscles are the most powerful in a bird's body? Why? 2. Why does a bird not fall from a branch even when it is asleep?

Skeleton. Because of their power of flight a number of peculiarities have evolved in the skeletons of birds.

The bones are distinguished by lightness and thinness; some are hollow and filled with air, considerably reducing their weight. This is very important for flight.

The *neck (cervical) vertebrae* are flexible and numerous, which makes possible very free movement of the head.

The *trunk vertebrae*, however, are rigid. Many are fused together, providing a powerful support for the wing bones.

The *tail* is made up of small, flexible *caudal vertebrae* and the *pygostyle* (*ploughshare bone*), where the remaining vertebrae are fused and provide a support for the large tail-feathers (rectrices).

The *chest*, which forms a rigid framework, is made up of the vertebral column, *ribs* and the *breastbone*, or *sternum*. The large sternum is well developed and protects most of the trunk from below, where it bears a vertical plate known as the keel. Both the sternum and the keel owe their prominent development to the fact that they provide an attachment for the powerful breast (pectoral) muscles which move the wings.

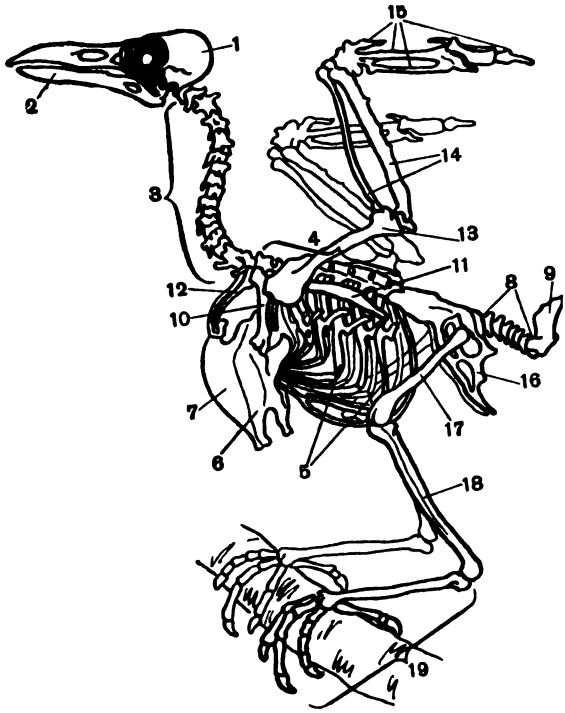


Fig. 111. The skeleton of a Rook, seen from the left side.

1. Skull. *2*. Lower jaw. *3*. Cervical vertebrae. *4*. Thoracic vertebrae. *5*. Ribs. *6*. Sternum. *7*. Keel. *8*. Caudal vertebrae. *9*. Pygostyle (ploughshare bone). *10*. Coracoid. *11*. Scapula. *12*. Wishbone, formed of fused clavicles. *13*. Humerus. *14*. Radius and ulna. *15*. Hand bones. *16*. Pelvis. *17*. Femur. *18*. Tibia. *19*. Foot bones.

The *skull* has a remarkably big *cranium* (*braincase*), which accommodates a well-developed brain. The *jaws* are drawn out to form a *beak*. There are no teeth. This reduces the weight of the head—an important factor in flight when the head is carried on the outstretched, rather long neck.

In the *skeleton* of the *fore limbs* we find the same sections as in other land vertebrates, but the bones that form the hand are rudimentary. This is explained by the fact that the fore limbs have been adapted for flight and evolved into wings.

The *shoulder girdle* (*pectoral girdle*) is well developed because of the action of the wings. It is made up of the large *coracoids*, which slope down to unite the wing bones with the sternum, the sabre-like

scapulae lying along the back, and the slender *clavicles* which unite to form the *wishbone*.

The *anatomy* of the *hind limbs* is characterized by a single *tarsometatarsus* formed by the union of most of the foot bones. The tarsometatarsus extends the hind limbs which support the bird on the ground and when perching (birds are bipeds).

The *pelvic girdle* enables the trunk to be supported and consists of large *hip-bones* rigidly connected to the backbone.

Questions: 1. Why are the cervical vertebrae flexible and those of the trunk rigid? 2. Why do we say that the wing is a modified fore limb of a land vertebrate? 3. What structural peculiarities have arisen from the power of flight?

§ 54. NERVOUS SYSTEM

The nervous system of the Rook follows the general pattern of the vertebrates and consists of the *brain*, the *spinal cord* and the *nerves* that branch out from them.

The behaviour of the Rook is much more complex than that of amphibians or reptiles. Birds build nests, incubate their eggs and take care of the young. Many migrate to warmer climates, covering enormous distances. To be able to do this they need a better-developed brain than the reptiles. Especially prominent is the *forebrain* with two cerebral *hemispheres* covering the *diencephalon* (*betweenbrain*) and a portion of the *mesencephalon* (*midbrain*) extending round to the large *cerebellum* at the back. The latter owes its prominence to the complicated process of flight. (What is it like in the frog?) As in other vertebrates, the *medulla oblongata* merges with the spinal cord.

Sight is very keen, which is essential during flight. The *sense of smell* is not well developed.

The advanced cerebral hemispheres make it easier for the Rook than for reptiles to form *conditioned reflexes*.

For instance, the sight of the upturned soil after ploughing is linked with the presence of food (insect larvae, earthworms), and Rooks fly to it, unafraid of the noise made by the tractor engine, in the same manner as their ancestors defied the farmer and his horse.

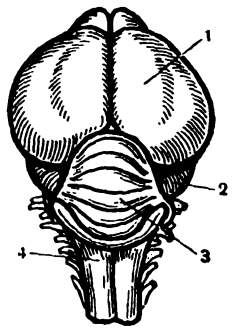


Fig. 112. The brain of a bird.
1. The cerebral hemispheres of the forebrain. *2*. Diencephalon (betweenbrain) *3*. Cerebellum. *4*. Medulla oblongata.

It is not difficult to develop conditioned reflexes in caged birds by feeding them from your hand, etc.

Questions: 1. Why do we say that the brain of a bird is better developed than that of a reptile? 2. How has the prominence of the cerebral hemispheres influenced the behaviour of birds? 3. Why is the size of the cerebellum important? 4. Which organs of sense are the most powerful? Why? 5. What conditioned reflexes do you know of in birds?

§ 55. INTERNAL ORGANS AND THEIR FUNCTIONS

Digestive System. Because the body of the Rook is adapted for flight, the same specific modifications are observed in its internal structures, as in its skeleton and external appearance.

In order to have energy for the muscles, which are constantly involved during flight, it is necessary to consume a large amount of food. Rooks and other birds have far greater appetites than reptiles and the process of digestion is much faster.

The food is not chewed (why?). Instead it passes down a long oesophagus into a muscular stomach.

In the seed-eating species, such as pigeons and domestic fowls, the *oesophagus* dilates into a *crop* in which the food is stored and softened before getting to the stomach. The Rook has no crop because its diet includes carnivorous food, and not seeds only.

The *stomach* consists of a *glandular portion* where the gastric juice is secreted and digestion begins, and a *muscular portion* (*gizzard*) with very *thick muscular walls* and a hard internal lining. The walls contract and serve to crush the food. This structure makes up for the absence of teeth.

The *small intestine*, which follows the stomach, is long. The ducts of the *liver* and the *pancreas*, which secrete digestive juices, open into the front part of the small intestine. Here the process of digestion is completed and the nutrient substances are *absorbed* by the blood.

The *large intestine* (*rectum*) is short and opens into the *cloaca.* The urinary and generative ducts also open into the cloaca—a general pattern for amphibians and reptiles. The undigested remains are excreted from the rectum at frequent intervals—a clear indication that the process of digestion is short.

The absence of teeth, the short rectum and frequent excretions diminish the weight of the body, making flight easier.

Questions: 1. Why do birds eat more than reptiles? 2. What modifications in the digestive system point to the power of flight? 3. How is the lack of teeth made up?

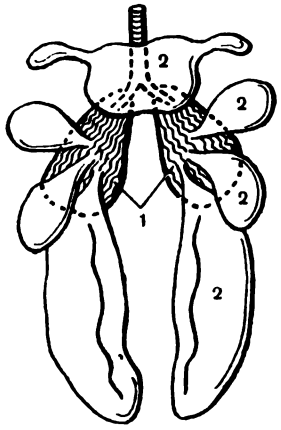


Fig. 113. Respiratory organs.
1. Lungs. *2.* Air-sacs.

Respiratory System. The *lungs*, two spongy pink organs, are situated in the thorax. They are more highly developed in birds than in amphibians or reptiles. The blood washing them takes in larger quantities of oxygen and excretes much more carbon dioxide.

Air is taken into the body through the *nostrils*, passes through the oral cavity and enters the long *trachea* (*windpipe*) which runs down the neck and divides into two *bronchi*. These enter the lungs and branch off into tubes. The walls of the trachea and bronchi contain cartilaginous rings which determine their shape and keep the air passage free.

The *vocal cords* lie in the lower part of the trachea, in a so-called *syrinx*, at the point where the two main bronchi begin.

The lungs of the Rook are linked with a system of large, thin-walled *air-sacs* which fill most of the body cavity (Fig. 113), extend to the skin and are even connected with air spaces in many of the bones. The bird's weight is reduced, flight and respiration are made easier.

When the bird is at rest, respiration is achieved by movements of the sternum. When the sternum falls, the thorax expands and air is drawn into the lungs and the air-sacs (*inspiration*); when it rises, the air-sacs and lungs are compressed and the air is pushed out (*expiration*).

This method of respiration is no longer possible in flight when the bird's chest is motionless. Then the air-sacs dilate as the wings are raised and pure air is drawn into them through the lungs (*inspiration*). They are compressed as the wings are lowered, and the air is pushed out (*expiration*). The faster the bird flies the more rapid is the flapping of the wings and consequently the greater the volume of air taken through the lungs. Birds never get out of breath. (What happens to your breathing when you run fast?)

Because of this arrangement, i.e., the presence of air-sacs, air goes through the lungs twice, and oxygen is consumed not only during inspiration but also on its way back. Birds have double breathing.

Questions: 1. How does air enter the lungs when a bird is at rest? 2. How do birds breathe during flight? 3. Why do birds never get out of breath? 4. Why do we say that birds have double breathing?

Circulatory System. The circulatory system is also more highly developed than that of the amphibians and reptiles.

The *heart* is big and has *four chambers*, not three, and is completely partitioned vertically into the right and the left sides. Each side consists of an *auricle* and a *ventricle*. Since there is no communication between the ventricles, pure and impure blood never mix. The internal organs always receive blood having a fair supply of oxygen.

Like in other land vertebrates, there are two blood circuits (Fig. 114).

The impure blood containing carbon dioxide flows out of the right ventricle by way of the pulmonary circuit to the lungs. In the lungs it gives off carbon dioxide and picks up a fresh supply of oxygen. From the lungs it returns to the left auricle. This is the *pulmonary (lesser) circulation.*

From the left auricle blood passes to the left ventricle, and is driven into the *big aortic arch.* By way of a network of branching *arteries* it reaches the *capillaries* in all parts of the body. It discharges oxygen, takes up carbon dioxide and returns along the *veins* to the right auricle. This circuit is known as the *systematic (greater) circulation.*

Pumped along the aortic arch blood supplies the body with fresh amounts of nutritive substances and oxygen, and removes (from the cells) carbon dioxide to the lungs, and toxic substances to the excretory organs.

Excretory System. The *kidneys*, which are large and long, lie on each side of the vertebral column, in the hind section of the back. The *ureters* lead to the cloaca. There is no urinary bladder. Urine, in the form of thick fluid, is excreted together with the faeces.

Metabolism. In Rooks and other birds, living processes are speeded up, the muscles function at a fast rate. The internal organs are much more active than in the reptiles. Digestion takes place quickly. Larger quantities of oxygen are taken into the blood because of the double breathing. The four-chambered heart pumps oxygen-filled blood to all parts of the body.

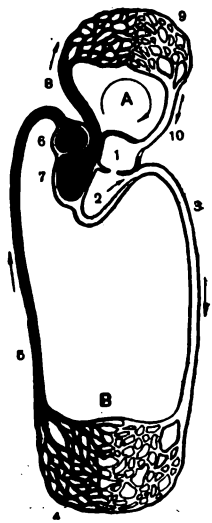


Fig. 114. Diagram of the circulatory system of a bird. *(A)* Pulmonary circulation. *(B)* Systematic circulation. *1.* Left auricle. *2.* Left ventricle. *3.* Arteries taking blood from the heart to various parts of the body. *4.* Capillaries. *5.* Veins by which blood returns to the right auricle *(6)*. *7.* Right ventricle. *8.* Pulmonary arteries. *9.* Pulmonary capillaries. *10.* Pulmonary veins through which blood flows back into the left auricle.

This mode of life requires greater expenditure of energy than that of fish, amphibians or reptiles. For this reason birds maintain a constant and high temperature (42—43°C, even 45°C), which is higher than that of mammals or man.

The speed of the process of metabolism can be seen in the following examples: an owlet can digest a mouse in four hours; a swallow will die if deprived of food for a single day.

Questions: 1. Why do we say that the circulatory system of birds is more complex than that of amphibians? 2. What is the advantage of the four-chambered heart of birds over that of the three-chambered heart of amphibians? 3. What is the meaning of the term "pulmonary circulation?" 4. How do birds profit from the absence of a urinary bladder? 5. What characterizes the process of metabolism in birds?

§ 56. REPRODUCTION AND DEVELOPMENT

Reproductive Organs. The sexes are separate, but male and female Rooks look alike. The organs of reproduction lie in the body cavity. The male's paired *testes* are lobed. The females have only one *ovary* which contains many small and large yellow bodies. These are *eggs* in various stages of maturity. When the eggs are mature they pass into a broad oviduct which opens into the cloaca.

The presence of a single ovary diminishes the body weight. The eggs do not develop at once, as is the case with reptiles, but one by one. This is also important in the general scheme of weight reduction.

Reproduction Period. In early spring the Rooks begin to repair their old nests or build new ones. They settle in tall trees in large communities. Some rookeries may have more than a hundred nests, built close to each other and to human settlements—in small groves surrounded by fields, where food supplies are ample. The nests are like fairly large baskets, and are made of twigs and sticks, which the birds break from the trees with their powerful beaks. Nest building is accompanied by loud cawing.

The pale greenish eggs spotted with brown are laid in April and are so marked that they are almost unnoticeable in the nests, when the female Rooks are away.

The development of embryos requires heat. The female sits on her four or five eggs for 17—18 days (incubation). When the young hatch out they are quite helpless and depend for a considerable time on their parents to supply them with food (mostly insects and larvae).

Embryology. The mature *egg* consists of yellow matter corresponding to *yoke.* It is passed into the oviduct where it meets the sperms

and is *fertilized*. It is then coated with *egg white* and a porous chalky shell. The embryo develops in the warmth of the mother's body. Birds' eggs differ from the ova of fish and amphibians in that a developing embryo is incorporated in each.

If the egg becomes cold, development of the embryo stops, and resumes only when warmth is again applied. Warmth is absolutely necessary for its development.

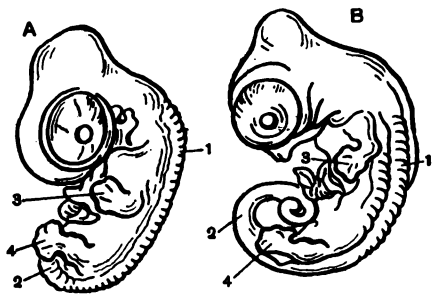


Fig. 115. Embryos.
(*A*) Of a bird. (*B*) Of a reptile. *1*. Backbone. *2*. Tail. *3*. Fore limbs. *4*. Hind limbs.

The developing embryo is fed on the food materials contained in the yoke and the egg white. It breathes oxygen which enters through the porous shell.

The early embryo (Fig. 115) looks more like a reptile than an adult bird: it has a long tail; its fore limbs do not resemble wings; its jaws are not drawn out to form a beak. All this is yet another indication that birds are related to reptiles.

The early embryo has *gill slits*, which proves that the primeval ancestors of birds lived in the water.

Questions: 1. Name the reproductive organs of birds. 2. What are the similarities between the reproductive organs of a bird and a reptile? What is the difference? 3. Describe the development of a bird embryo. 4. Why do we say that bird and reptilian embryos resemble each other? What conclusion can be drawn from this?

§ 57. EVOLUTIONARY RELATIONSHIPS

Birds and Reptiles. When comparing the structure of living birds and reptiles we see at once that they bear a close resemblance to each other and, also, that birds show considerable advances.

Both groups of animals are closely related. This relationship is further confirmed by the structure of birds which lived in ancient times and have been unearthed with other animal fossils.

Archaeopteryx. Imprints of an ancient bird about the size of a pigeon have been found in the Mesozoic strata. The skeleton bore a closer resemblance to a reptile than to present-day birds. The animal was called *Archaeopteryx*—"*the first bird*".

Examine Figure 116. Fossil evidence proves that the body was covered with *feathers*, the fore limbs had been transformed into

Fig. 116. Archaeopteryx.
Left—fossilized imprint; *right*—outward appearance. *1*. The three clawed fingers on the wings. *2*. The four toes on the legs. *3*. The many vertebrae of the tail. *4*. The toothed beak.

wings, each leg carried a *tarsometatarsus* and four toes, of which three were turned forwards and the fourth in the opposite direction.

The animal was neither reptile nor bird, but a combination of both. There were three prominent clawed *fingers* on each wing, apparently to catch hold of the branches while climbing trees, and a long tail with a row of *vertebrae* and feathers along each side (not growing fanwise, as they do today.) The skull was bird-like, but the beak was lined with small reptilian *teeth*.

The fact that the bones were heavy and solid, the keel undeveloped, and the *sternum* weak indicates that the bird was a poor flier, mostly gliding from branch to branch. The wing muscles must also have been weak.

The find shows clearly that birds evolved from reptiles. It is even easy to trace their evolution.

Some of the fossil reptiles were only able to run on their hind limbs. Gradually they learnt to climb trees, which led to the development of long fingers one of which was curved in the opposite direction from the others—to grasp a branch. As they jumped from one branch to another, they learnt to spread their fore limbs like a parachute to cushion the fall. Jumping was made easier by the long scales that covered the limbs. The scales developed into feathers, and the fore limbs into wings.

The presence of wings and the transition from jumping to flying led to other important modifications: the development of the breast muscles, the growth of the sternum, the emergence of the keel, and the disappearance of the teeth. Active life caused more energetic metabolism and complicated changes in the internal anatomy.

Questions: 1. Why can we classify the Archaeopteryx as a bird? 2. What was there in common between the first birds and the reptiles? 3. What can you say about the evolution of birds?

Despite the general similarity in the structure and anatomy of the living types of birds, there is a great diversity of bird forms, resulting from habitat and mode of life. This becomes clear even on the basis of a few examples.

The Common Swallow. The Swallow family are among the most expert fliers. The *Common Swallow* (Fig. 117) spends all day long on the wing catching food—gnats, flies and other insects—during flight by means of a wide-open small beak, well adapted for the purpose. When the weather is dull and cloudy, Swallows pursue insects flying quite close to the ground; when the day is clear and bright, they rise high in the air. A typical bird of the air, the Swallow can drink and bathe during flight, skimming the surface of the water with exquisite grace and great speed.

The Common Swallow is very agile in flight. It can hover and glide, dart upwards or swoop downwards, wheel in a wide arc or turn sharply.

It alights on the earth when it wants to collect damp soil to build a nest.

Flight is made easy because of special structural modifications: powerful breast muscles, streamlined body, long wings and a long tail. The wings are so long that when folded they extend far beyond the trunk. The tail is very deeply forked in the centre and serves as an excellent steering mechanism.

The legs are weak and short, and are only used to grip the nest with the little sharp claws.

Eggs are laid and incubated in nests built under projecting roofs and attached to walls or rafters—i.e., in spots protected from unfavourable weather and enemies. The nests are formed skilfully of moist earth or silt, collected bit by bit and plastered together with saliva.

Towards the end of summer, when the days are growing shorter and food becoming scarce, Swallows migrate to warmer climates—Africa or South Asia—to return the following spring, as the heralds of coming warmth.

Fig. 117. Common Swallow and its nest.

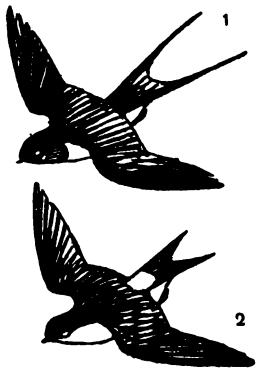


Fig. 118. Common Swallow and House Martin on the wing.

The energetic activity of the muscles during the day-long flights requires an abundance of food. A family of Swallows consumes about a million harmful insects during one summer. Therefore, Swallows are very useful birds.

The Common Swallow is distinguished from the *House Martin* by a more deeply forked tail and a chestnut marking on the throat (Fig. 118). The House Martin has a pure white throat and a splash of white on the tail.

Questions: 1. Why do Swallows fly low when rain is near? 2. What is there in a Swallow's anatomy to indicate its splendid power of flight?

The Ostrich of Africa. The anatomy of the *Ostrich of Africa* is quite different. It belongs to the order of flightless birds but is able to run at great speed.

The Ostrich of Africa (Fig. 119) is by far the largest of living birds. A fully grown specimen stands 2 m. 75 cm. high to the top of its head, and may weigh 75 kg. It lives in open country and feeds on seeds, as well as insects and lizards. It can travel through the desert for several days without water.

It sometimes runs over very long distances in search of food and water. Ostriches depend on their fleetness for security. They can easily jump over obstacles; when alarmed they can run faster than a horse.

The long, muscular legs are perfectly suited to carry the bird at a very great speed on land. They have only two padded toes which are not easily injured and are not affected by the hot desert sand. People are reported to have been killed by blows from the legs.

The wings are rudimentary and the ability to fly has long been lost. Ostriches use their wings only when running—either as a steering mechanism when making sharp turns, or as sails, when there is a favourable wind. Full-fledged wing remiges (oar feathers) have been replaced by long fluffy plumes similar to those in the tail.

The powerful development of the legs is a result of intensive exercise over many generations; the rudimentary state of the wings is the result of the opposite process.

The structural modifications in the wings and corresponding muscles have been duly reflected in the skeleton: the breastbone (sternum) has no keel and the pectoral (shoulder) girdle is rather weak.

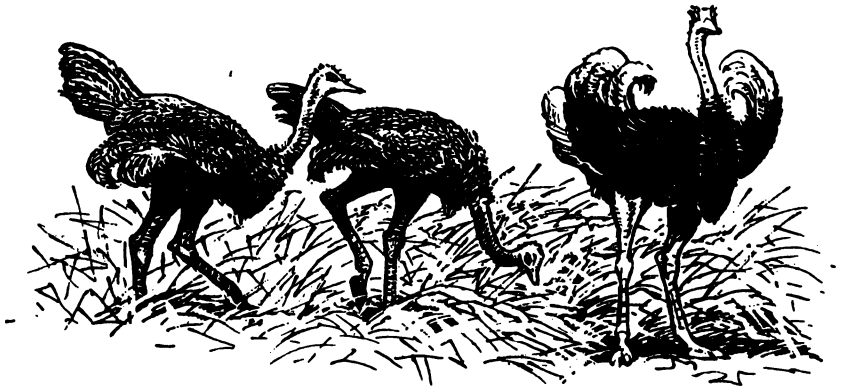


Fig. 119. Ostriches of Africa.

The process of the lengthening of the legs was accompanied by the lengthening of the neck. If the neck were short the Ostrich would be unable to pick up food from the ground. Its height, very keen sight and the fact that it lives on the plains make it possible for it to see an enemy a long way off.

The hen lays large eggs (twenty times the size of those of the domestic hen) in a hollow in the sand surrounded by a slight rampart of pebbles. The eggs are enclosed in hard shells.

During the day the eggs are incubated by the hen: they are dusky-grey and hardly discernible against the sand. The male has glossy black plumage, with wing and tail-feathers of white; he is more conspicuous and takes care of the eggs at night.

Ostriches are hunted for their magnificent white feathers, and are also bred on special farms. Their flesh and eggs are used as food.

In the USSR, Ostriches of Africa live in Askania-Nova, a steppe reservation in the Ukraine.

Questions: 1. Why are the legs of the Ostrich so powerful and the wings rudimentary? 2. How can you explain the fact that female Ostriches have a modest appearance while the males are very showy?

Mallard. *Mallards* (or, as they are generally called, *Wild Ducks*) live on and near quiet streams and shallow ponds overgrown with water-plants (Fig. 120), which offer them plentiful food and comfortable nesting sites.

This bird has a body perfectly suited to aquatic existence. It is broad and flat like a boat. The legs are short and the three front toes webbed. When a duck swims its legs are extended far rearwards

Fig. 120. Mallards.

and serve as a steering mechanism, while the outstretched webs are used as oars.

Ducks are excellent swimmers but on the ground they look quite clumsy. Because their legs are set far apart they have a characteristic waddling gait.

Belonging to the category of waterfowl, the duck never gets wet. Its feathers are greased with oil secreted by an *oil gland* situated at the base of the tail. The bird presses the gland with its beak, squeezes out the oil and spreads it over the feathers by continuous preening.

The duck remains warm even when swimming in cold water because beneath the contour feathers the body is clothed in soft underfeathers and down (which has very short shafts). The warm coat of underlying down acts as an excellent insulation from the cold. The layer of fat under the skin serves the same purpose.

The thick plumage and abundant fat help to reduce the density of the duck's body and makes swimming easier.

Ducks live on vegetable matter and small animals (molluscs, insect larvae, small crustaceans, and tadpoles) which they fish out of the water with the beak. The beak is broad and flat, and is provided with horny plates along the edges. Water, which is taken in with the food, is not swallowed but sieved through the plates.

The edges of the beak and its tip, which is bent over like a hook, are hard; the upper and lower surfaces are soft. Owing to the presence of numerous sensory nerves in the beak, it serves as an important organ of touch helping the bird to find its food in water and silt.

Nests are usually made near water, on the ground, in thick grass. As soon as their down dries out after hatching, the ducklings are able to follow their mother and forage a great deal for themselves.

Female ducks have dull brown feathers which protect them from discovery while they are sitting on their nests. The males, called drakes, have much brighter colouring.

The winters are spent in warmer regions (such as the southern coast of the Caspian Sea), where water does not freeze. In spring the ducks migrate northwards, to colder, temperate parts.

Questions: 1. Why do we say that ducks are well adapted to an aquatic existence? 2. What do they feed on? How is their food obtained?

Fig. 121. Great Spotted Woodpecker.

Great Spotted Woodpecker. This bird is widely distributed throughout the woodlands. It spends its life in the trees (Fig. 121), looking for the larvae and beetles that hide in the bark and timber, and the insects to be found on leaves. It is also fond of coniferous seeds.

The bird's anatomy is suited to its mode of life. The feet of the Great Spotted Woodpecker are armed with sharp claws, and the position of the toes is different from that of most other birds: two are directed forwards and two backwards—an important adaptation for clinging firmly to the tree bark, the stiff, pointed, vane-like tail feathers serving as support.

The legs and tail give the woodpecker three points of support. Its ability to place its legs wide apart assists it in clinging.

The legs and tail enable the bird to stand firmly while it taps away noisily at a tree trunk.

Its tongue is long, slender and sticky, and is equipped at the tip with tiny sharp outgrowths curving up backwards. With this it extracts insect larvae out of the bark and wood. The smaller insects stick to the tongue and bigger ones are caught on the outgrowths as if on a fork.

The bird breaks open pine cones with its beak in order to get the seeds. It often places the cones in a hole in a tree trunk left by a dry branch which has fallen off, or in the fork of a branch. Woodpeckers' "workshops" can easily be detected by the presence of a great number of cones scattered under the tree.

Woodpeckers are useful birds because they feed on insect pests. The harm they do by eating pine seeds is compensated for by the number of harmful insects they destroy.

They lay their eggs in holes made in decaying parts of trees. This is another useful habit because the nests are subsequently used by other harmless birds. The nest is lined with tiny chips of wood.

Questions: 1. What structural peculiarities have developed in the body of the woodpecker because it lives in trees? 2. Are woodpeckers useful? Why?

§ 59. NESTING HABITS AND MIGRATION

Nesting Habits. The overwhelming majority of birds build nests. A few merely dig a hole in the earth and lay their eggs in it. Nests range all the way from wonderful creations to very simple ones. (Remember the nests of the rooks, swallows, ostriches, and woodpeckers.)

After the eggs are laid, the task of sitting on them is usually undertaken by the female. In some species (Ostriches of Africa) this duty is shared by the male.

The hatchlings are helpless and require considerable care.

Chickens and *ducklings* have a covering of feathers, wide open eyes and well-developed limbs, when they hatch out. They are able to follow their mother and forage for food. These young birds are called *precocial* because they follow their mother in a group (brood).

The mother protects them from beasts of prey, helps them find food, and keeps them warm at night and shelters them from rain by spreading her wings over them.

The young of other birds (*rooks*, *swallows*, *pigeons*, *starlings*) are born quite helpless: naked and in most cases blind (when they emerge from the shell). They must be fed by the mother for a certain period. They cannot be led forth but remain in the nests, and often both parents bring them food throughout the day. These hatchlings are called *altricial*. Their parents belong to the category of birds which cannot provide food for a large brood and generally lay few eggs.

There is one bird, however, which does not make a nest for itself. This is the *Cuckoo*. Its eggs are small for its size (the Cuckoo is about as big as a jackdaw). It lays one egg in the nest of a small "favoured" bird (flycatcher, wagtail, etc.). These little birds rear the young Cuckoo which grows fast, devours all the food brought by the foster parents, and throws out its fellow nestlings, to whom the nest rightfully belongs. Young Cuckoos are far bigger than the birds which are forced to take care of them (Fig. 122).

Fig. 122. Flycatcher feeding an "adopted" cuckoo.

This shows that the behaviour of birds is automatic obedience to the demands of "blind" instinct. It might seem logical for the little foster parents to notice the presence of the strange chick but they do not and continue to raise the intruder.

Fig. 123. A flock of migratory cranes.

Migration. The life of many birds is correlated with seasonal variations.

In summer many birds are to be found in the woodlands of the temperate zone. In August, when the weather is still warm and signs of the coming autumn are barely noticeable, the first of the migratory birds, the *swifts*, depart. The next to go are the *swallows*, which gather in swarms before departure. The last to leave, shortly before the advent of winter with its hoar frosts, are the *geese* (Fig. 123) and *cranes*.

After spending the winter in warmer climates they fly home again in spring. The earliest to return—in March, when the snow has barely begun to melt—are the *rooks*. They are followed by the *starlings*, *skylarks*, *ducks*, *geese*, *cranes* and so on. The homecoming procession ends with the *swallows* and *swifts*—the first to leave.

All these birds make their nests and rear their young in certain countries, and move for the winter to others, sometimes a long distance away. Swallows and cuckoos fly to Africa; starlings to Western Europe; ducks, geese and swans—generally to the coast of the Caspian Sea (where special reservations have been established). These periodical movements, undertaken by *migratory birds*, follow definite routes.

Sparrows, *jackdaws*, *hazel-grouse* and *black grouse* are *resident* throughout the range of their distribution.

Many kinds of birds move from one place to another at certain seasons of the year in search of food. The crimson-chested *bullfinches*, for instance, come to the central regions of the Soviet Union in winter and leave to breed in colder parts in spring. *Great tits* and *great spotted woodpeckers* sometimes fly very long distances. However, their movements, which do not follow definite routes, should not be termed migrations. They are usually spoken of as "*irruptions*".

Some birds, for instance, the *hooded crow*, appear to reside in one place, but have been discovered to possess migratory or even irruptive habits. The hooded crow spends the summer near Leningrad and

leaves to winter in Germany and France, making room for its more northern relatives.

Why Do Birds Migrate? The reasons are varied and complex. Migration is often connected with unfavourable conditions, i.e., the cold of autumn and winter. But the reason is not so much cold (birds maintain a sufficiently high body temperature) as the scarcity or total lack of food. Swallows and swifts can find no insects, there is nothing for the ducks, geese and cranes, because the rivers, lakes and swamps are covered with ice; rooks have no way of getting food after the soil becomes frozen and stiff, or disappears under a thick covering of snow.

The changes in external conditions force the birds to leave.

Behaviour during migration is governed by hereditory instincts. Young birds find their way without any guidance in their first autumn. Some, for instance, starlings, set off well before their parents.

The evolutionary history of these instinctive annual movements is believed to have begun in a geologically ancient period when the climate underwent a drastic change, and the bird population was pushed south. Under certain conditions the instinct may die. Wild ducks, living uncaged on the ponds at the Moscow Zoo, display no desire at all to fly south in autumn: they "know" that in winter they will be provided with an abundant supply of food.

Bird-banding. Exact information about the seasonal movements of birds is obtained through *bird-banding.*

A bird is caught and a light, numbered, aluminium ring, bearing the name of the institution concerned, is put on one of its legs before it is set free. The finder of a dead, ringed bird is requested to send the ring and a report to the institution.*

General Characteristics. Most *birds* possess the power of flight and are well adapted to ground movement. Their bodies are covered with feathers. The fore limbs have been modified into wings.

The anatomy of birds is more developed than that of reptiles. The four-chambered heart and powerful lungs (equipped with air-sacs) provide a constant supply of oxygen-filled blood to all the organs. Metabolism is extremely energetic. The body temperature is steady. The brain is quite well developed. Behaviour is distinctively complex.

Reproduction is effected by laying large eggs and incubation.

Scientists have described over 8,000 species of birds, which have all been brought into one class.

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* In the USSR this is the Bird-banding Bureau: 12 Kravchenko Str., B-331 Moscow, c/o Nature Protection Commission under the USSR State Planning Committee.

Questions: 1. Why is it that the precocial birds rear more hatchlings than their altricial counterparts? 2. What is a migratory bird? Resident? Irruptive? 3. What are the characteristic features of the Class Birds?

§ 60. IMPORTANCE TO MAN

Useful Birds. Nearly all birds are useful. Exceptions are the *goshawk*, the *sparrow hawk* and the *marsh harrier*, which hunt useful birds, and the *crow* and the *magpie*, which destroy the nests of ducks, geese and partridges.

Insectivorous birds (*swallows*, *woodpeckers*, *starlings*, *titmice*, etc.) catch tremendous numbers of harmful insects. One titmouse, for example, can eat its own weight in 24 hours (Fig. 124). One family of starlings daily consumes over 350 caterpillars, beetles and snails, which would otherwise cause damage to forests and fields. In one hour a *cuckoo* can devour about a hundred hairy caterpillars which other birds ignore.

The demand for insect food grows enormously during the breeding season: the young grow very fast and are always hungry, so that from dawn to dark their parents busily carry them food. One woodpecker has been observed flying to its nest some 300 times in one day with food.

Many seed-eating birds (*goldfinches*, *siskins*) also serve a useful purpose by feeding their hatchlings on insects. Some, for instance goldfinches, eat large quantities of weed seeds in winter.

Many birds of prey, which hunt either by day or at night (*owls*, *hen hawks*), are beneficial for they eat small mammals—mice, field-mice, susliks. It is estimated that one owl annually consumes as many mice as would devour a whole ton of grain. *Kestrels* and *merlins* prey mostly on small rodents, such as mice, but also attack locusts and other insect pests.

Bird-keeping. Birds belong to the category of man's friends. They must be protected and encouraged to come into gardens, fields, orchards, and afforestation belts.

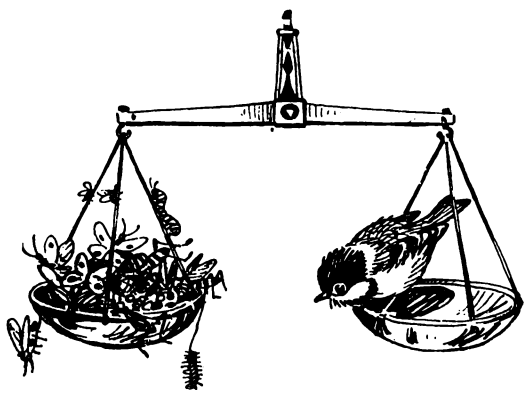


Fig. 124. Titmice are useful. They eat their body weight of insects in one day.

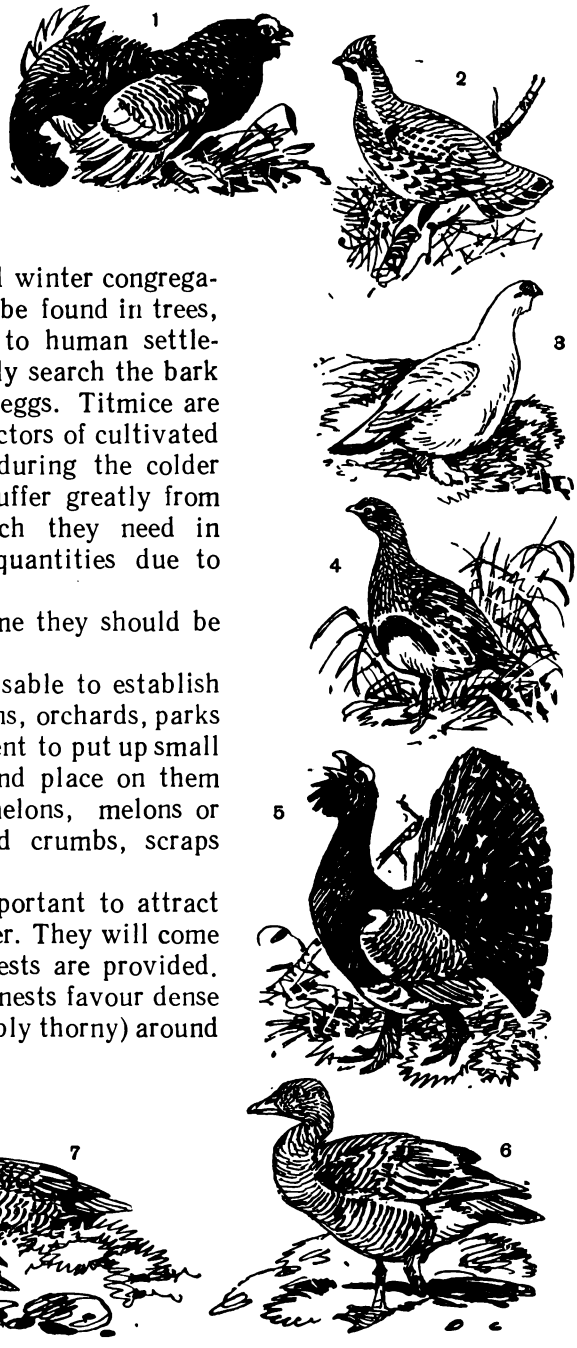


Fig. 125. Game birds.
1. Black Grouse. *2*. Hazel-grouse. *3*. Snow Partridge. *4*. Grey Partridge. *5*. Great Grouse. *6*. Wild Goose. *7*. Eiders.

In late autumn and winter congregations of *titmice* are to be found in trees, sometimes quite near to human settlements. They incessantly search the bark for insects and insect eggs. Titmice are the most vigilant protectors of cultivated plots. Unfortunately, during the colder snowy months, they suffer greatly from shortage of food (which they need in considerably greater quantities due to the cold weather).

At this difficult time they should be taken care of and fed.

In winter it is advisable to establish feeding places in gardens, orchards, parks and woods. It is sufficient to put up small table-like structures and place on them the seeds of water-melons, melons or hemp, as well as bread crumbs, scraps of unsalted lard, etc.

It is even more important to attract birds during the summer. They will come if suitable sites for nests are provided. Those that make open nests favour dense shrubs. Hedges (preferably thorny) around

the gardens are most suitable. Artificial nests can be put in suitable places for birds that prefer bag-shaped, roofed homes (or make their nests in hollow trees).

The size and shape vary. Man-made nests are especially important for the small insectivorous species—*titmice*, *redstarts*, and *spotted flycatchers*.

High posts should be erected in the fields and young plantations for birds of prey—to help them detect rodents.

It is the duty of schoolchildren to take an active part in protecting and encouraging bird colonies throughout the four seasons of the year. In autumn they can store food: seeds of wild plants, berries of mountain ash, white thorn and wild rose. In winter they should set up bird tables and place food on them. In spring they can build nests in their school workshops.

Every school should observe Bird Day. On this day children should examine and clean old nests and hang up new ones. They can also organize a party to tell younger children about useful birds, and also why it is wrong to destroy nests. In summer it is advisable to watch the behaviour of birds that will have come to the nests prepared for them.

Thorny shrubs should be planted in school gardens and on collective farms, to attract birds for nesting.

Game Birds. Many birds in the Soviet Union are hunted for their feathers and down and because they are good to eat. Some are shot in great numbers. These are known as *game* (Fig. 125).

Game-shooting varies in different parts of the vast territory of the country. *Hazel-grouse*, *great grouse* and *black grouse* are found in woodlands; *snow partridges* in the tundra; *ducks* and *geese* in the vicinity of lakes and rivers.

Feathers and down are also used commercially, especially the beautifully soft eiderdown, which is excellent for stuffing quilts and padding clothing. The *eider* is found along the northern sea coasts. Its down, which it plucks generously to line its nests, is carefully collected.

To prevent wanton slaughter which could lead to the extermination of game birds, hunting is prohibited during the egg-laying and rearing season, and in case of ducks and geese—also during moulting when the birds become quite helpless and are unable to fly. Some species (*swans*, *great grouse*, etc.), which have become rare, are protected at all times (in many parts). Limitations are imposed on the amount of the daily bag.

Special *reservations* have been established, where game-shooting is banned altogether. (On the Astrakhan Reservation in the delta of the Volga a great many game birds can nest and moult unmolested, or make a stop on their migration routes.)

Questions: 1. Why do we say that birds are beneficial to farmers? 2. How can birds be encouraged to stay in gardens and fields? 3. What is understood by a game bird? 4. Where and how is eiderdown obtained?

§ 61. FOWL

Wild Fowl. The domestic fowls of today were evolved from the wild *Red Jungle Fowls* which are still found in the forests of India, China and Burma, and resemble the familiar chickens both in outward appearance and behaviour. They are heavy, thick-set birds with powerful legs carrying several blunt claws. The head is adorned with a comb and wattles. The cocks are bigger than the hens and have more beautiful plumage.

The Red Jungle Fowl, like its domesticated relatives, finds its food by scratching in the earth. Its diet consists of seeds and insects. Its powers of flight are poor and it uses its short, rounded wings only to leap onto a tree branch to escape from beasts of prey, or when roosting at night.

In the wild state fowls reproduce by laying a clutch of eggs in a nest in some hidden place on the ground. The newly-hatched chicks are fairly independent and are able to pick up food.

Evolution. The wild ancestors of the modern fowl are believed to have been domesticated in India somewhere about 5,000 years ago, after which they were gradually introduced to all countries throughout the world.

During this time, various types have been developed. Domestic hens, although they have much in common with the Red Jungle Fowl, lay more eggs and are much heavier (which is most important). The Red Jungle Fowl weighs 600—800 gr., while the domestic breeds weigh from 2 to 5 kg. The Red Jungle Fowl lays about 12—20 eggs a year; the domestic hen about 300, i.e., 15 times as many. Minor changes concern colour, the shape of the comb, etc.

The greater size and capacity to lay more eggs are the result of good food and proper care, and generations of selective breeding. These qualities were often inherited.

Breeds. Gradually various types of fowls have been evolved.

The most popular in the USSR is the *Russian White*, which lays about 200 eggs a year and sometimes even up to 320. The breed was evolved at Soviet collective and state farms from Leghorns, but is heavier and better adapted to our climate.

Other breeds popular in the USSR include the *May First*, white birds with a dark tail; *Rhode Island Reds* (chestnut), and the *Yurlov Singers*, the cocks of which have powerful vocal cords. The Yurlov

breed was evolved in pre-revolutionary times by peasants in the Oryol Region. The birds are heavy, lay up to 200 eggs a year, and stand up well to cold weather.

Questions: 1. What do domestic fowls have in common with the Red Jungle Fowl? 2. What difference is there between them? 3. What conditions brought about the changes in the wild fowl in the process of domestication? 4. Which fowls in the Soviet Union have the greatest commercial importance?

§ 62. CARE OF POULTRY

Housing. Domestic fowls are kept on collective and state farms in special *poultry houses.* These are built in elevated, dry places, usually on the outskirts of a village, some little distance from human homes.

Some poultry houses have special grassy runs and the birds are allowed to go on "free range".

The houses are built of wood, bricks, slag, or a mixture of clay and reeds (saman), and have floors and ceilings adapted for winter. If the birds are not caged there is no need for heating. If birds are kept in cages, and are thereby forced to live without exercise, the house must be heated.

All the houses have *windows* and are well lit because daylight is most important for the birds' health. In winter *electric lights are switched on* in the morning and evening to prolong the hours of light. This causes the birds to lay more eggs.

Another important condition is the presence of fresh air, which is achieved through *ventilation.*

To prevent disease (infectious microbes can be brought in on the poultry-farmers' shoes) special grids covered with thick felt or sawdust saturated with *disinfectant solution* are placed at the entrances.

Equipment. On some farms fowls *live uncaged on the floors* of sheds. At others *they are kept in cages.* Different equipment is required for each method.

When the birds are kept in separate *cages,* the cages are arranged in rows and tiers, and the shed in which they are kept is called *a battery-laying house* (Fig. 126). This arrangement allows for greater mechanization in caring for the birds.

Fresh water flows slowly along a small open trough extended along the rows of cages. This saves the poultry farmers much work and ensures a clean water supply for the birds. Special appliances deliver the food to the troughs mounted in front of each cage. *Mechanized scrapers* remove the droppings.

Fig. 126. A battery laying house.

The eggs, laid on the wire-mesh floor which is slightly sloped, roll towards the front where they are stopped by a special barrier. Collection is quick and simple.

To prevent disease and make them lay more eggs the fowls are regularly exposed to radiation from *quartz lamps.*

The *feed troughs* and *drinking vessels* for birds on *free range* are placed on the floor or on special stands so made that the birds cannot get inside them. Receptacles that supply food and water automatically and just need regular filling are, of course, the most convenient.

In some cases fowls are allowed to roost on *perches*, which are installed not higher than 70—90 cm. above the floor (most domestic fowls are poor fliers), and at the same level—so that they do not become soiled by droppings.

Nests are usually boxes partly filled with straw. On pedigree farms poultrymen use trap-nests for control. When a hen enters the nest to lay an egg the door closes behind her and holds her until

she is released. This makes it possible to record the number of eggs laid by each hen and choose the eggs of the better layers for incubation.

Shallow boxes filled with *sand* or *cinders* are placed on the floors of laying houses. The hens sit in them and "dust" themselves to become free of vermin.

The floors in the poultry houses are commonly covered with *straw*, *peat* or *sawdust*. These materials absorb the moisture in the droppings. Some farmers add fresh material as necessary throughout a whole year, clearing it all out at the end of the year and adding a completely new layer for another 12 months (the so-called *multi-layer method*).

Feeding. Like their wild ancestors, domestic fowls need different components in their diet. Grain and offals (bran, middlings) combined, in smaller quantities, with *animal matter* provide the best diet. On smaller farms, fowls that are allowed to run free find much of their food themselves: insects, earthworms, etc. On larger farms they are fed partly on dried ground waste meat (meat meal) or fish (fish meal) from slaughter-houses, and sometimes earthworms, molluscs, and May-beetles. Peas and other legumes, which are rich in protein, can be used to replace part of the animal matter.

Vitamins are supplied in *juicy food*: carrots and beet, as well as *green food*: grass, sprouted barley and oats, as well as special vitaminised preparations. In winter they get V-flour made of dried grass.

The shell of an egg is largely made up of *minerals*, which are fed to the bird in the form of chalk, broken shells of molluscs, and bone meal. The diet must also include some salt.

Mineral matter and *grit* must be placed in separate boxes. Fowls have no teeth with which to break up food. Instead they have a gizzard—a strong muscular bag. The grit they swallow is stored in the gizzard, where it helps to grind up the food as it passes slowly through.

The diet must be carefully regulated depending on each bird's weight and egg-laying record. The larger the bird the more food it needs. Food is also needed to make eggs.

Specialists have evolved special *diets* for fowls of different ages, weights and egg-laying capacities. The fowls are fed two or three times daily.

Special equipment is used to prepare the food—vegetable root washers, root cutters, steamers, mixers.

Time-table and Personnel. Poultry farms are staffed with specially-trained poultrymen, who feed the fowls, collect the eggs, and keep the houses clean. If the farm is not mechanized, a larger staff is needed. On highly-mechanized farms (mechanized water and food supply, and the clearing away of manure) one person can take care of about 10,000 fowls. Naturally, this lowers the cost of eggs and poultry.

Each farm keeps to a strict daily time-table in carrying out the work of feeding, airing the houses, cleaning the troughs, etc.

Specific Requirements. Poultry breeding must be based on the biological peculiarities and requirements of each separate type.

Since the ancestors of the domestic fowl came from India, a country with a warm climate, poultry sheds must always be warm, well-lit and airy. Surrounding the house there must be a run protected from rain and excessively hot sun.

Since the fowls are almost unable to fly, the perches must not be too high, and the feeding troughs must stand on the floor.

Taking into consideration the food requirements (inherited from their wild ancestors), fowls must be fed not only on a vegetarian diet but also on animal and mineral matter.

Only if the foregoing provisions are carefully observed will fowls have fine flesh and lay many eggs.

§ 63. DUCKS, GEESE, TURKEYS

Ducks. *Ducks* are also very useful because they provide meat, eggs, feathers and down.

Ducks belong to the family of water-fowls and are mostly bred near water (a river or a pond), where they can swim, find plenty of duckweed and other vegetation to eat and many small animals (for instance, larvae of water insects).

Ducks bred for the table grow very quickly and reach a weight of about 2 kg. when 2 months old.

The domestic breeds are all descended from the wild *Mallard.* While retaining many characteristics of their ancestors, improved characteristics have been bred into them. Ducks today are bigger and fatter, have lost their migratory instinct and lay more eggs.

The finest of all table breeds, the *White Pekin Duck*, was bred in China (Fig. 127).

Geese. *Geese* are also very easy and profitable to keep. Except during the winter they can graze on meadows and pastures, and do not require additional feeding. In autumn, after the grain crops are harvested, they can be pastured in the fields.

Domestic geese are the descendants of wild *Grey Geese*, but the breed has been greatly improved.

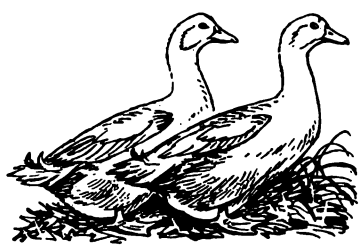


Fig. 127. Pekin Ducks.

They are larger and fatter, and have largely lost the ability to fly. Because they are provided with adequate food throughout the four seasons of the year, they have completely lost the urge to migrate.

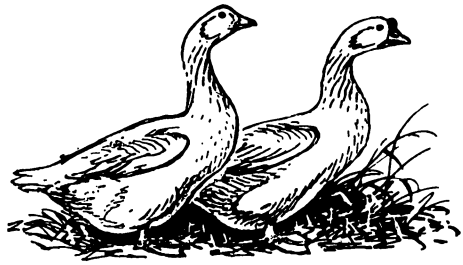


Fig. 128. Domestic Geese.

There are quite a number of fine table breeds in the USSR, for instance the *Arzamas Geese* (Fig. 128), and various crosses between local and Chinese species.

Turkeys. *Turkeys* are valued for their tender, juicy meat. They are heavy birds and, like fowls, have short, sturdy legs and short wings.

The head and part of the neck are bare and furnished with wattles. A thick wattled outgrowth above the beak is more prominent among cocks. Under excitement the colour of this prominence changes to purple and red due to the heavy flush of blood.

Turkeys are natives of the southern parts of the USA, where they are still found wild. They were introduced into Europe after the discovery of the American continent. The fact that they emerged from very warm climates comparatively recently still has a certain effect on their health. Turkey chicks do not stand up to cold and damp well, and often fall victim to disease.

The most popular breed in the Soviet Union are the large *North Caucasian Bronze* (the cocks weigh up to 12 kg.), which are well adapted to the local climate and are reared on free range (Fig. 129).

Questions: 1. Why do we say that ducks and geese are useful commercially? 2. In what way have geese and ducks changed since domestication? 3. What breed of turkeys has been bred in the USSR? Why is it good?

§ 64. INCUBATION AND ITS IMPORTANCE

Hen 'Sitting'. Certain conditions are necessary to cause a bird embryo to develop. Incubation provides these. By sitting on the eggs, the hen heats them by her body warmth. To regulate the tempera-

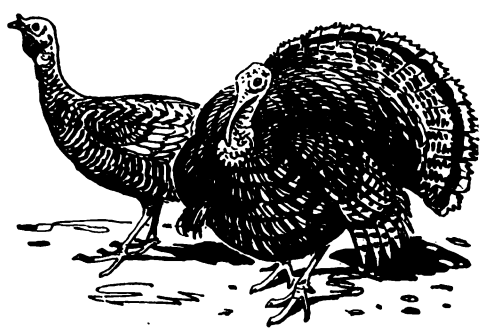


Fig. 129. North Caucasian Bronze.

ture, she turns all the eggs with her foot and beak and shifts their places: from the centre to the flanks and back. The air under her body is always moist and the eggs do not become dry and there is always enough fresh air: from time to time the hen leaves the nest for food and water.

Incubators. A hen cannot sit on more than 20 eggs at once. This rate is quite unacceptable on modern poultry farms where thousands of birds are kept. Eggs are hatched there in large quantities in *incubators*, which are like heated cupboards (or, in some cases, rooms) in which the eggs are placed on special shelves.

In an incubator conditions are very similar to those under a sitting hen. The eggs are heated, fresh air passes around them, there is a sufficient amount of moisture, and the eggs are regularly turned from one side to another.

Large poultry farms have huge cabinet-type incubators which hold thousands of eggs. They are heated by electricity, and the eggs are kept on numerous trays along the walls. The required temperature, humidity, ventilation and the turning of the eggs are all controlled automatically.

The principle of artificial incubation was discovered thousands of years ago, in Egypt and China. It was not until the 19th century, however, that it was used in practice. In the Middle Ages scientific progress was considerably delayed by the church authorities. When an Italian physicist invented a machine to hatch eggs, he only narrowly avoided being put to death, and the incubator was burnt. Religion regarded science as a bitter enemy.

In our country artificial incubation of poultry was practically introduced only after the Great October Socialist Revolution.

Today hatcheries incubate chicks, ducklings, baby turkeys, and goslings.

Rearing. Young incubated chicks need proper care. They must be "mothered". They cannot keep themselves warm for very long. Usually they are put into special heated compartments, called "brooders".

Very quickly, they learn to pick food from troughs, and will run to them as soon as the poultry maid comes in. Her appearance becomes linked with food—a chain of new, conditioned reflexes are developed, which greatly helps in the rearing process.

If the incubated chicks are surrounded with warmth, and are fed and taken care of properly, they will grow as fast as those which are hatched by a hen.

Questions: 1. What conditions are created for the eggs when they are incubated by a hen? 2. What is the advantage of an incubator? 3. Can chicks be taught to come running at the sound of a stick beating against a pail?

Chapter Ten

CLASS MAMMALIA

§ 65. RABBITS. EXTERNAL FEATURES AND GENERAL BEHAVIOUR

Wild and Domestic Rabbits. Rabbits belong to the highest class of vertebrates, the *Mammals*. The *domestic* breeds were derived from wild rabbits, which are still widespread in the south of Europe. They were brought from there by man to the South-Western Ukraine, where they are still found in small numbers. Wild rabbits live in colonies on hillsides overgrown with scrub, and in ravines. They dig burrows in the ground where they sleep, rear their young and seek shelter from their enemies.

Rabbits live on vegetation. They stay in their burrows during the day, coming out at dusk (or at night) in search of food.

Anatomy. Locomotion. Domestic and wild rabbits look very much alike. The body is divided (a feature common to all mammals) into a head, neck, trunk, tail, and two pairs of limbs. The trunk and the head (which bears two long ears) are linked by a short neck.

In a sitting position, with its legs crossed and back curved, a rabbit looks rather small and broad. In fact, however, it has quite a long body. It differs from reptiles in that its body is elevated from the ground by the limbs (this is common to all mammals).

The rabbit moves forward by hopping and stamping the ground with its hind legs which are much longer than its front legs, as is the case with all leaping quadrupeds (why?). The limbs have the same sections as those of other land vertebrates (which?). On the digits are horny claws. The front ones are particularly well developed and used to dig burrows.

Skin. The body is covered with *hair*, a feature peculiar to mammals. The hair protects the animal from cold and helps to maintain a steady body temperature. Some of the hair is long and in the form of bristles (*guard hairs*); the *undercoat* is short and soft. Like

the scales of reptiles and the feathers of birds, hair consists of horn. (How can this be proved?)

Like other mammals, rabbits have *moulting periods* when the hair falls out and new hair grows. It is thickest in winter.

The skin contains *grease glands* which secrete substance that makes the hair soft and pliable and protects it from dampness and wet.

The skin also contains *sweat glands* which, in rabbits, are less developed than in other members of the class. The sweat evaporates from the skin helping to keep the body cool in hot weather.

Lying along the belly of the female (doe) are several pairs of teats connected to the *mammary glands* which supply milk to suckle the young. The mammals owe their name to their characteristic feature, the presence of mammae—milk-secreting organs.

Sense Organs. Wild rabbits are surrounded by enemies. They are hunted by foxes, polecats and birds of prey. They are also hunted by people.

Rabbits always look around to see if it is safe. At the slightest hint of danger they scamper into their burrows, which are interconnected forming a maze of passages. Rabbits can often escape even when enemies have found the entrance to their home. At the approach of an enemy, a rabbit drums the ground with its hind legs to warn the other members of the colony. (Have you ever noticed tame rabbits behave in the same manner when they are scared?)

The rabbit's sense of hearing is very acute. Its auditory organs are

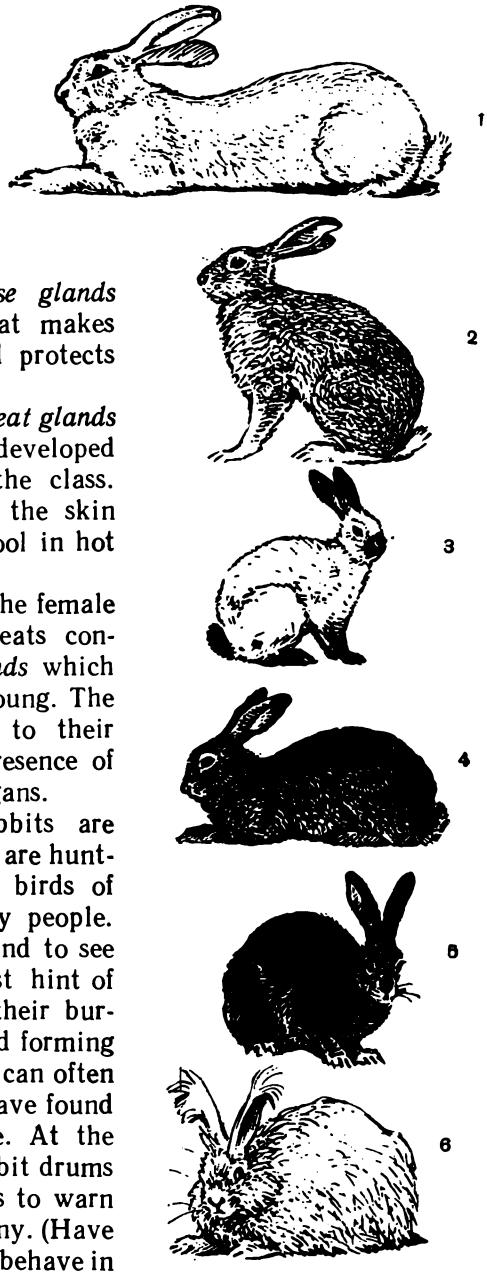


Fig. 130. Rabbit breeds.
1. Flemish Giant. *2*. Chinchilla. *3*. Russian Ermine. *4*. Silver Fox. *5*. Sable. *6*. Angora.

better developed than in reptiles or birds. Moving its large *outer ears* (*pinnae*) in different directions, the rabbit catches sound waves. The outer ears surround openings which lead through *external auditory canals* terminating in *eardrums*. Sound waves cause the eardrum to vibrate. These vibrations are conducted by the *earbones* (*auditory ossicles*) to the *inner ear*, where they are delivered to the *acoustic nerve-ending*. All the parts of the ear, except the outer ear, lie within the skull bones.

Like other mammals, the rabbit has a keen *sense of smell*, which plays a very important part in its life, helping it to find food. The olfactory organs, which serve as the sense of smell, are located in the nasal cavities. There the olfactory nerve-endings, that run to the brain, branch out. The nostrils are at the end of the snout, which is always moist. The rabbit constantly sniffs the air to pick up scents.

The *eyes*, located on each side of the head, have movable upper and lower *lids* with a few *eyelashes*. This arrangement protects the eyes from injury and dirt.

Both on the upper lip and above the eyes are bunches of coarse hair (vibrissae) which correspond to the "whiskers" of the cat. These serve as *organs of touch*.

Breeds. Domestic rabbits, which are all descended from wild breeds, resemble their ancestors in anatomy and behaviour. In captivity, they still dig burrows; if kept in hutches, they choose the darker side in which to make a nest. If danger threatens they vigorously strike the ground with their hind legs.

The domestic breeds are larger, of a greater variety of colourings, and produce hair of different qualities. They are bred for their *fur*, for *meat*, and for *wool*. The meat of all rabbits is good to eat (Fig. 130).

Questions: 1. What does a rabbit look like? 2. What is there in common between hair, reptile scales and bird feathers? 3. What sense organs are most acute in a rabbit? 4. What features of the rabbit's external anatomy are typical of all mammals?

§ 66. SKELETON AND MUSCLES

Skeleton. In its main features the skeleton of the rabbit resembles those of other land vertebrates, but also has peculiarities characteristic of all mammals.

The *backbone* is composed of vertebrae and is divided into five sections: the neck, chest, loin, hip, and tail.

All mammals have *seven* flexibly connected cervical vertebrae in the neck, whether they are rabbits, giraffes or moles. The differ-

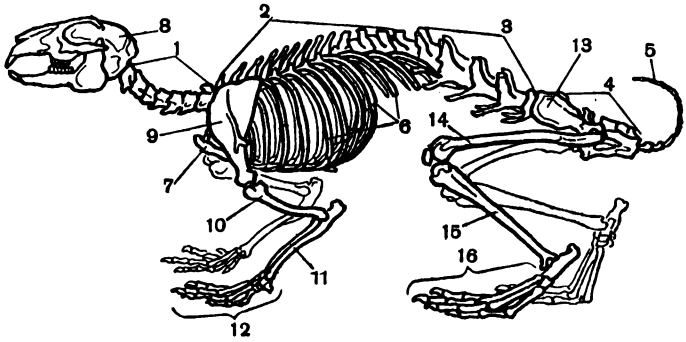


Fig. 131. The skeleton of a rabbit.

1, *2*, *3*, *4* and *5*. Backbone. *6*. Ribs. *7*. Sternum. *8*. Skull. *9*. Scapula. *10*. Humerus. *11*. Radius and ulna. *12*. Phalanges. *13*. Pelvis. *14*. Femur. *15*. Tibia and fibula. *16*. Phalanges.

ence in the length of the neck is due to differences in the length of the vertebrae.

The vertebrae in the chest section have the *ribs* fixed to them. The other ends of the ribs are attached to the *sternum*. These together form the thorax, a convenient protection for the heart and lungs. There is no keel.

The *lumber vertebrae* are large and at the sides bear a pair of transversal expansions which have fused with the ribs.

The *hip vertebrae* are fused into a solid bone which is known as the *sacrum*, and serves as a base for the attachment of the pelvic girdle.

The *tail vertebrae* are small.

To shelter the well-developed brain, the cranium (braincase), which is part of the *skull*, is quite large. The mouth is big and equipped with teeth.

The *pectoral girdle* consists of clavicles (collar-bones) and scapulas (shoulder-blades). The *scapulas* have no ligaments attaching them to the backbone. This allows great freedom of movement for the fore limbs. The *clavicles* are slender and short, and are absent in most mammals.

The *coracoids*, so prominent in birds, are also absent (a feature common to all mammals). They can be traced in the embryo but are later fused with the scapulas.

The fore limbs have the same bone structure as other land vertebrates: the *humerus*, the two *forearm bones* (*radius* and *ulna*), and the numerous *phalanges*.

There is a large *pelvic girdle* (*pelvis*) which is an excellent support for the hind limbs.

Attached to the pelvic girdle is the *femur*, the two *lower leg bones* (*tibia* and *fibula*), and the numerous *phalanges*.

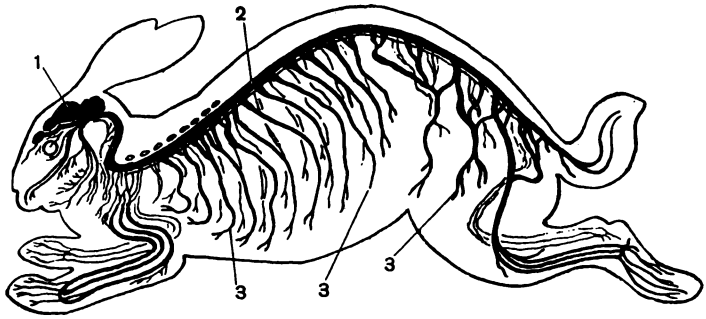


Fig. 132. The nervous system of a rabbit.
1. Brain. *2*. Spinal cord. *3*. Nerves.

Muscles. The muscles are attached to bones. When they contract they pull the bones in different directions. Muscles vary considerably in size and shape (the rabbit has several hundreds of different descriptions).

The most powerful muscles are located in the hind limbs (why?). Those of the neck and back are also well developed.

Questions: 1. What do the skeletons of the rabbit, frog and bird have in common? 2. In what way is the bone structure of the rabbit typical of other mammals? 3. Which muscles in the rabbit's body are the best developed and why?

§ 67. NERVOUS SYSTEM

The *nervous system* of the rabbit (and other mammals) is characterized by a well-developed brain, which has the same sections as those of other vertebrates.

The *forebrain* which consists of two very large *cerebral hemispheres* (Fig. 133) is most prominent. The surface of the hemispheres is made up of nerve cells which form the *cerebral cortex*.

In the rabbit the cortex is smooth, but in other mammals, for instance the dog, it is furrowed to increase its size.

The considerable development of the cerebral hemispheres and the cortex is linked directly with the

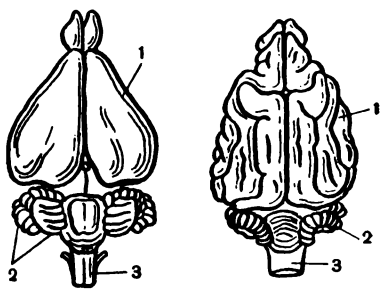


Fig. 133. The brains of a rabbit (left) and a dog (right).
1. Forebrain. *2*. Cerebellum. *3*. Medulla oblongata.

intricate behaviour patterns of the mammals. *Conditioned reflexes* are easily developed. Rabbits will stand on their hind legs in front of the barred cage doors as soon as they hear sounds normally associated with feeding (steps, the cutting and washing of vegetables, etc.).

The *cerebellum* is large, consists of several sections and forms a shield (together with the hemispheres) for all the parts of the brain.

Questions: 1. Which parts of the mammalian brain are most prominent? 2. Why are brain furrows of the cerebral hemispheres important?

§ 68. INTERNAL STRUCTURE

Body Cavity. The *body cavity* of the rabbit contains the bulk of the inner organs and is divided (a feature common to all mammals) into two sections: the *chest* and the *abdomen* separated by a muscular partition, the *midriff* or *diaphragm*.

In the chest, or thorax, lie the *lungs* and the *heart*; in the abdomen—the stomach, the intestine, kidneys, and other organs.

Digestive System. The rabbit eats vegetable matter which is not highly nutritious and is difficult to digest. This is reflected in the anatomy of its digestive system.

The *mouth* is surrounded by thick *lips* with which food is picked up. A division in the centre of the upper lip is important because it gives protection from injury when the rabbit gnaws hard substances. Lips, which are absent in other vertebrates, are typical of the anatomy of mammals.

The oral cavity is equipped with teeth coated with very hard enamel. The teeth are not all alike.

In the front of the upper and lower jaws there are two pairs of long, sharp *incisors*. The incisors of the rabbit (Fig. 134) are curved and deeply embedded in the jaws. They are capable of crushing tree bark and even wood without being dislodged. Nor, because of the thick enamel at the front, do they become blunt. The enamel is thinner at the back, where it wears off faster. Incisors never become short because as they are worn down at the top, they grow continuously from the base. In the upper jaw the first pair of long incisors has a second pair—smaller ones—hidden behind them.

The teeth lying at the back of the jaw (*grinders*) have broad, ridged tops. They act as millstones for grinding food.

The incisors are separated from them by a wide gap. In some mammals this is where the *canines* are located. These teeth are particularly formidable in beasts of prey.

It is only in mammals that teeth are modified in different ways (incisors, canines, grinders). In other vertebrates they are identical.

The food taken into a mammal's mouth is broken up in the process of chewing. Some animals swallow their food without chewing. In the process of chewing, the food is moistened by saliva which is secreted by *salivary glands*. The saliva is a digestive juice. Therefore we can say that the process of digestion begins in the mouth cavity.

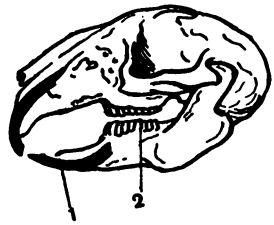


Fig. 134. The teeth of a rabbit.
1. Incisors (blackened). *2*. Grinders.

Crushed into smaller particles and moistened, the food proceeds, with the help of a thick *tongue*, through the *pharynx* and the *oesophagus* into the *stomach*, where digestion continues under the influence of gastric juice.

The stomach communicates with the *intestine*. In the rabbit the intestine is a long tube which is divided into several sections. The ducts from the *liver* and *pancreas* open into the first section—the *small intestine*. The juices secreted by them and by the walls of the small intestine almost complete the process of digestion.

The small intestine joins the *large intestine*, which is connected to the final section, the *rectum*. The rectum terminates with the *anus*.

At the junction of the small and large intestines is a very large tube, called the *blind gut*, ending in a small, *worm-like projection*, the *appendix*. In this region food, which is most difficult to digest, is broken down by the action of bacteria.

Once the food has been digested, the nutritive substances are *absorbed* into the blood stream.

The rabbit's intestine is 15 times as long as its body. The presence of a long intestine and a large blind gut is typical of plant-eating mammals: vegetable food contains only small amounts of nutritive substances and is not easy to digest. Flesh-eating mammals have much shorter intestines and a less-developed blind gut.

Questions: 1. How are the teeth of mammals classified? 2. What are the peculiar features of the rabbit's incisors? 3. How has the rabbit's intestine been modified to digest vegetable food? 4. Which parts of the intestine are involved in digesting food?

Respiratory Organs. The *lungs* of the rabbit, which are enclosed in the chest, are fairly well developed. Air is taken in through the *nostrils* and passes through the *nasal cavity*, the *pharynx*, the long *trachea* and the *bronchi* to the lungs. The walls of the trachea and the bronchi are lined with cartilaginous rings which keep both from collapsing.

Inspiration and expiration are brought about by the contraction and relaxation of the diaphragm and the muscles lying between the ribs. The muscular diaphragm is dome-shaped and protrudes into the chest. When it contracts it is pulled downward and the dome is flattened. Simultaneously the ribs are raised by the contraction of the muscles lying between them. The cavity of the chest is enlarged and inspiration takes place. When the muscles are relaxed, the size of the chest cavity becomes smaller, and expiration is brought about.

At the upper end of the trachea is the *larynx* (voice box), a cartilaginous structure which offers support for the *vocal cords.* The vocal cords are stretched bands of tough tissue which vibrate and produce the different sounds made by the various mammals.

The lungs contain a dense network of capillaries, therefore the actual exchange of gases is extremely active.

Circulatory System. The circulatory system of the rabbit is in many ways similar to that of birds. The *heart* has four chambers. Blood circulates along two circuits: the systemic (greater) circulation, from the left ventricle throughout the body and back to the right auricle; and the pulmonary (lesser) circulation, from the right ventricle to the lungs, and back to the left auricle.

Since the two sides do not communicate with each other, the pure, oxygen-filled blood pumped by the left part of the heart is never mixed with that of the right which is saturated with carbon dioxide. Due to this all the organs are supplied with blood which has been oxygenated in the lungs.

The circulatory system is linked with the *spleen,* which manufactures certain blood components.

Excretory Organs. The *kidneys* of the rabbit are located in its abdominal cavity, on either side of the backbone, and look like beans.

As the blood passes through, the substances that form urine are removed. Urine flows through the *ureters* into the *urine bladder,* from which it is regularly discharged.

Questions: 1. Describe the mechanism of inspiration and expiration. 2. What is the role of the numerous bronchioles in the rabbit's lungs? 3. How is the rabbit's circulatory system organized? 4. What is the advantage of a four-chambered heart over a three-chambered one? Describe the process that takes place in the kidneys.

Metabolism. *Metabolism* is the chemical changes which go on ceaselessly within the body of the rabbit and other animals.

In the rabbit (and other mammals) these changes are extremely energetic. In the lungs, blood is supplied with considerable quantities of oxygen. Because the heart is divided into two parts, which do not communicate, the cells are supplied with oxygenated blood.

In each cell there is an active utilization of amino acids and considerable amounts of energy are released. The body temperature of mammals is kept at a steady level, that is, somewhat lower than that of birds.

§ 69. REPRODUCTION AND DEVELOPMENT

Embryonic Development. As in other vertebrates the sexes are separate. *Ovaries* which produce *egg-cells* (*ova*) are female reproductive organs; *testes* which produce *spermatozoa* are male reproductive organs.

Fertilization takes place inside the body of the female, in the *oviducts*. The fertilized egg-cell, or embryo, then finds its way into the *uterus* where it starts to grow (Fig. 135).

The layers covering the embryo are drawn into the uterine wall and nourishment at the expense of the mother begins. At the place of attachment the blood vessels of the developing embryo lie very close to those of the mother (but do not unite). Through the thin walls of the two sets of blood vessels an exchange of nutritive substances and oxygen (from the mother) and carbon dioxide and other waste products (from the embryo) continually takes place. The uterus protects the mammal's embryo from harmful outside effects.

After about a month the development cycle is completed.

Development of the Young. At birth the young are naked, blind, unable to run about or find food for themselves. The mother (doe) plucks fur from her body to line the nest to make it warm. The litter sucks the doe's milk, which contains all the substances essential for growth. The young grow fast. Soon their eyes open and their bodies become coated with fur. When about 3 weeks old they are able to leave the nest and eat vegetable matter. In 5—6 months they are fully grown and ready for mating.

If properly fed, a female rabbit can produce several litters of 5 to 8 young in a year.

General Characteristics of Mammals. The mammals constitute the highest *class* of vertebrates. All carry some hair, have a four-chambered heart and a constant body temperature.

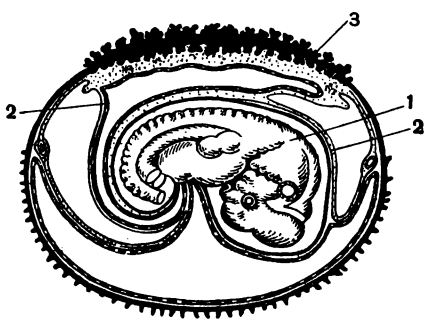


Fig. 135. The uterus of a rabbit.
1. A 12-day-old embryo. *2*. Layers. *3*. Blood vessels of the embryo and the mother lying side by side.

The large front lobes of the brain are well developed and are covered with cerebral cortex. Behaviour is complex; conditioned reflexes are easily developed.

The teeth consist of incisors, canines, and grinders.

Except in the very lowest forms, the young are born and then nourished with milk supplied by the mother for some time. This, of course, is a higher form of reproduction than hatching from eggs.

Scientists have described about 6,000 species of mammals.

Questions: 1. How is the rabbit's embryo nourished? How does it breathe? 2. In what way do rabbits of 3 weeks differ from the newly born? 3. What are the advantages of giving birth and suckling? 4. What are the characteristic features of the mammals as a class?

§ 70. PROTOTHERIA (EGG-LAYING MAMMALS)

Some primitive mammals do not give birth to their young but lay *eggs*. However, when the young hatch out, they are fed with milk. These belong to Prototheria (the subclass of primitive *egg-laying* mammals). One is the *Duck-billed Platypus* (Fig. 136), which lives in Australia.

Duck-billed Platypus. The Duck-billed Platypus is a small animal (its body measures about 60 cm. from the tip of the beak to the tip of the tail). It owes its name to the shape of its jaws, which are drawn out into a broad duck's *beak*, covered with a horny layer.

The animal lives along the edges of rivers and spends most of the time in the water. It uses its beak to search the bottom mud and silt for molluscs, worms, and insect larvae. The adult animals have no teeth: teeth are present in the young but are later replaced by horny plates, which are very useful for crushing mollusc shells.

The Duck-billed Platypus swims expertly with the help of its *webbed* feet. The broad, flattened tail serves as a rudder. The dark-brown fur is so thick that water does not get through and the animal is always dry. The outer ears (pinnae) are absent; when the animal dives the earholes are closed. All these modifications are very effective for obtaining food in the water.

Reproduction. The Duck-billed Platypus burrows a chamber in a river bank opening into the water, and lines it with hair. Here the female lays two small *eggs* with leathery shells like those of reptiles, and sits on them. The young are hatched naked, blind and helpless, and are nourished for a time from milk secreted by the mother.

The *mammary glands* are more primitive than in other mammals. The mother has no teats. She lies on her back while the young climb onto her belly, squeeze out the milk with their beaks and lick it,

instead of sucking it in the usual way.

When the young grow up they accompany their mother out of the nest to get used to an aquatic existence.

Fig. 136. Duck-billed Platypus.

The group of egg-laying mammals is very small, consisting of just a few species limited to Australia and the neighbouring islands.

Questions: 1. What features help the Duck-billed Platypus to live in the water? 2. Why is the Duck-billed Platypus said to be a mammal? 3. What is there in common between the reproduction of the Duck-billed Platypus and the rabbit? What is the difference?

§ 71. MARSUPIALIA (POUCHED MAMMALS)

There is also a big difference between the *marsupials* and other mammals, one of the most important representatives being the *Great Grey Kangaroo* (Fig. 137).

Mode of Life. The kangaroo is a heavily-built animal (its body is almost 2 metres long), covered with thick grey fur (a great attraction for hunters). Kangaroos are found only in Australia, where they live on the plains and in the bushland.

When a kangaroo is not moving, it sits on its hind legs and is supported by its tail.

When grazing, it uses both pairs of limbs, and moves slowly. However, it can also travel at great speed. When propelled by its powerful hind legs it makes enormous flying leaps. When trying to escape from its enemies it easily jumps over bushes and ditches, using its tail as a helm.

Reproduction. The kangaroo is a big animal but when the young is born it is scarcely bigger than a walnut. It is blind, naked and completely helpless. At once the mother takes it in her mouth and places it in a *pouch* formed by a fold of skin on the underside of her body and enclosing the *mammary glands*, where it firmly grasps a teat. The teat becomes swollen and the young clings firmly to it.

As the "baby" is too weak and helpless to suck, milk is squeezed into it by the contraction of special muscles. This continues until the young is developed enough to become detached from the teat and to suck by itself. After about 8 months it is able to face the world,

and feed on grass. However, at the approach of danger it will immediately retreat into the mother's pouch.

Animals like kangaroos which give birth to immature offsprings and carry them, for a certain period, in a pouch, belong to the order of marsupials. Marsupials today are found principally in Australia. A small number live in America.

The fact that young marsupials are born so undeveloped indicates that they are more primitive than other representatives of the class. With the egg-laying animals they belong to the *lower mammals* (*Metatheria*). The higher mammals give birth to better-developed offsprings, capable of sucking milk.

Origin. The peculiar features inherent in the Duck-billed Platypus and the kangaroo give us a clue to the past history of mammals. Obviously, the two main characteristics—the secretion of *milk* to suckle the young and *giving birth* to the young—must have developed in the course of a long evolution. The egg-laying mammals nourish their young with milk but lay eggs like reptiles. The marsupials produce underdeveloped offsprings, carrying them for some time in pouches. Only in the higher mammals are the young well developed at birth. The anatomy of the mammary glands also varies, growing more complex depending on the orders. The Duck-billed Platypus, for example, has not even teats.

The egg-laying mammals are similar to reptiles in certain other respects too. The genital and urinary ducts of the Duck-billed Platypus open into the *cloaca*; the shoulder girdle has a *coracoid* which in other mammals is undeveloped and fused with the shoulder-blade; the body temperature is *not constant*, fluctuating between +24° and +34° C.

The anatomy and reproduction of egg-laying mammals suggest

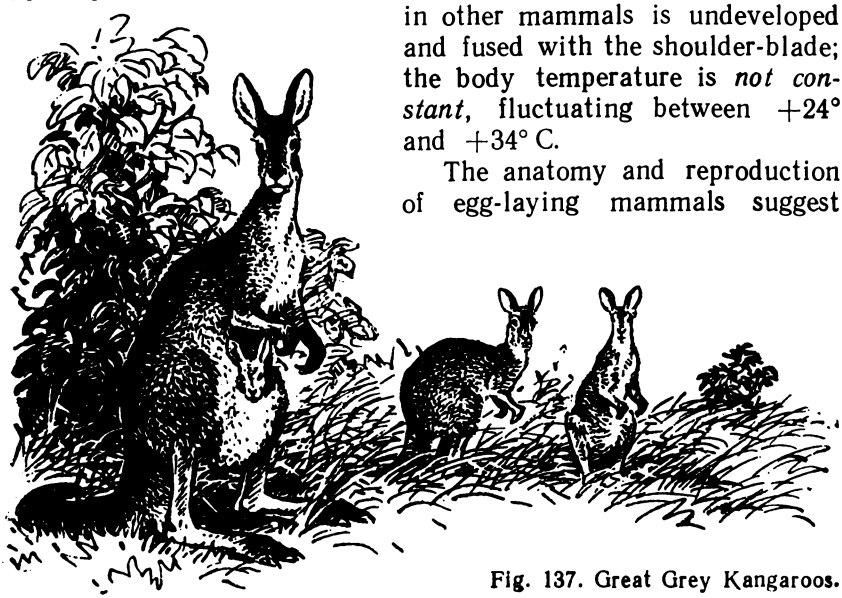


Fig. 137. Great Grey Kangaroos.

that they developed from ancient reptiles. This supposition is confirmed by the discovery of fossilized *Theriodontia* reptiles, which had differentiated teeth (incisors, canines and molars).

Questions: 1. What can you say about the reproduction of kangaroos? 2. Which animals belong to lower mammals? How do they differ from the higher mammals? 3. Why do we say that mammals have developed from ancient reptiles?

§ 72. INSECTIVORA (INSECT-EATING MAMMALS)

The common representatives of this order of mammals are the mole (Fig. 138), hedgehog, shrew, and some other small animals.

The *Mole* scarcely ever appears above ground. It excavates elaborate, long burrows and eats earthworms and insect larvae which come its way.

It digs with its fore limbs, which are short and turned outwards, unlike those of other animals. The palms face the posterior end of the body. The fingers have strong, sharp claws and are linked together by a leathery membrane. The fore limbs are like broad shovels, enabling the mole to scoop out the soil with great ease. The tunnels are cleared by pushing out the unwanted soil with the head. (Have you ever seen the mounds which moles make by burrowing underground?)

The mole has a pointed head on a cylindrical body, a clever adaptation for burrowing through the soil. The fur is so thick that the skin is well protected against dust. It is also soft and velvety, and the hairs can lie either way, which is convenient for animals that tunnel through the earth.

The diet consists mostly of earthworms and insect larvae, which are found in the tunnels. The small, sharp teeth crush the chitinous sheathes to pulp. The teeth are almost identical—a feature common to all insect-eaters. A fold of skin falling from the upper lip protects the mouth from earth when the mole is burrowing.

Of the sense organs, those of *smell* and *touch* are the most developed. The head carries a small *snout* with the nostrils in front. Both sides of the snout are lined with *sensory tentacles*. The senses of smell and touch are most important for an animal living underground and searching for food in total darkness.

The *eyes* are small, undeveloped, and deeply buried in the fur. They are not at all important, and the mole is only able to distinguish darkness from light.

There are no outer ears. The ear openings are closed preventing earth from getting in. The sense of hearing, however, is quite acute.

The nests are made in the earth, and in spring the female gives

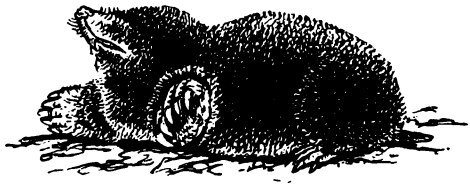


Fig. 138. Mole.

birth to some 3—5 young—small, naked and blind.

The suckling continues for about a month.

Moles are useful because they hunt insect pests, notably the larvae of May-beetles. They are also harmful because they eat "soil-cultivating" earthworms, damage plant roots and spoil the fields by making mounds and ridges of broken ground.

Moles are trapped for their fur which is used to make hats, collars, and coats.

Questions: 1. What are the modifications in the mole's body enabling it to live underground? 2. Why is it said that moles are useful and harmful at the same time?

§ 73. CHIROPTERA (HAND-WINGED MAMMALS)

The members of this order are bats, the only mammals which are able to fly. Food is caught on the wing. Bats never land.

The commonly-found *Long-eared Bat* (Fig. 139) demonstrates how well the anatomy and habits of bats are adapted for flight.

The Long-eared Bat's leathery *wings* are formed by a delicate *membrane* which connects their long fingers, and is carried back to join their hind limbs and tail. The only part not connected by skin is that between the fingers of the hind limbs and one finger of the fore limb. The wings are set into motion by powerful breast muscles. As in a bird, the sternum bears a *keel* (why?).

The bones are thin and light.

During the day the Long-eared Bat, and other bats, hang by their toes, head downward, in quiet nooks (caves, garrets, or hollow trees). At dusk they fly off for food and do not take a rest until morning. The diet consists of flying insects: moths, beetles, mosquitoes, etc., which they crush with their small, sharp teeth.

The *eyesight* of the bat is poorly organized. When hunting insects it relies primarily on its *sense of hearing*. A bat whose eyes had been covered by adhesive bands proved able to make its way with obvious ease in a room across which a number of bells had been strung. The animal did not collide with any of them. It has been found that besides the ordinary sounds, bats emit and collect *ultra-sounds*, too high-pitched for us to hear. During flight, they send out high-frequency waves. When these waves strike an object, no matter how

small, they are reflected back to the ears of the bat. From the signal, the animal knows where obstacles are and changes the course of its flight.

Fig. 139. Long-eared Bat.

In winter, when insects become scarce, Long-eared Bats take shelter in some warm spots and *hibernate*—usually in gardens, barns, caves, cellars, etc., hanging by their feet—head down. The process of metabolism becomes very slow and proceeds at the expense of fat accumulated during the summer. Some bats prefer to spend the colder seasons in warmer climates.

In early summer the female gives birth to young, usually one or two. For some time she carries them about: they hold fast to her breast without hampering her flight.

As bats destroy a great number of harmful insects, they should be encouraged. In a way they "work in shifts" with day-time insect-pest eaters—swallows and swifts. All these animals must be in every way protected.

Questions: 1. What is the difference between the wing of the Long-eared Bat and a bird? 2. What structural modifications are linked with the ability of the bat to fly? 3. Why do Long-eared Bats hibernate in winter? 4. Why should the Long-eared Bat and other bats be protected?

§ 74. RODENTIA (GNAWING MAMMALS)

The Order Rodentia is comprised of a large group of small mammals which includes rabbits, squirrels, hares, susliks, rats, and mice. Rodents are found all over the world where there is vegetation to live on. Some are useful, others are not.

Fig. 140 Squirrel.

Squirrel. The most useful rodent is the *Squirrel* (Fig. 140), a slender beautiful animal hunted for its fur. It has a bushy tail and long brush-pointed ears.

In summer the squirrel is chestnut-red, to match the bark of the coniferous trees where it lives. In autumn, when it moults it changes colour, and is covered

with thicker fur of different shades of grey, which makes it almost unnoticeable among the snow-covered branches and twigs. The winter pelt of the squirrel is used to make warm, soft and beautiful fur.

Squirrels keep to wooded districts and live in trees, leaping from branch to branch and even from tree to tree with extraordinary agility, assisted by their longer hind legs. The tail serves both as a rudder and parachute supporting the body in the air. The limbs are armed with small, sharp claws adapted for climbing trees, clinging to trunks and holding the smaller branches.

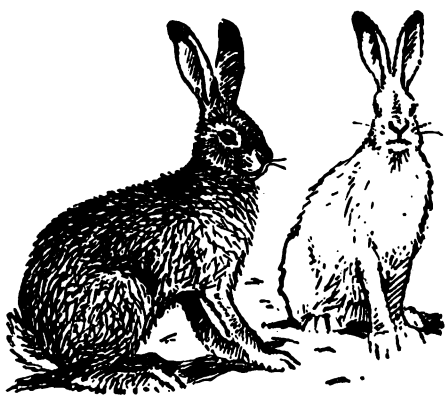
Squirrels eat pine and spruce seeds. When the harvest of cones is poor they leave that area and may travel considerable distances in search of a more favourable environment. They also eat cedar and other nuts, acorns, and mushrooms (which they string on tree branches in summer, to dry).

The teeth resemble those of a rabbit. They are characterized by long, sharp *incisors*, which crush nuts easily, and *molars*, which they use to grind food. There are no canines—a feature typical of all rodents. The incisors and grinding teeth are divided by a toothless gap. However, the smaller incisors, which are found in the rabbit's mouth behind the big ones, are absent.

Nests are built as a shelter from bad weather, and also in which to raise the young. They are usually made in hollows in trees or else in higher branches (from twigs and moss). Squirrels do not hibernate because they store enough food for winter.

Hares. Hares (Fig. 141) are hunted for their flesh and fur, which is cheaper than that of the squirrel.

The *White Hare* lives in the woods. In summer its colour is chestnut-grey, gradually changing in the autumn and winter to white, except the tips of the ears which are always black. The white fur makes the animal hard to see in the snow.



Hares look very much like rabbits. They have the same sitting posture, but their hind legs are considerably longer. The ears are long and the tail is quite short.

They move by making long leaps. The broad, thickly-furred soles of the foot make for ease of movement on soft snow.

Fig. 141. Hares.
Left—Grey Hare; *right*—White Hair.

They eat vegetable matter including tree bark. The *teeth* resemble those of the squirrel plus two small upper incisors (like the rabbit).

The White Hare generally sets out on its foraging expeditions at night, spending most of the day concealed in some convenient place in the undergrowth, called a "form". Returning to its "form" the White Hare does not run straight but doubles back on its track a number of times and also makes a series of long, sideways leaps, to break the scent. This helps in escaping from its numerous enemies—foxes and wolves. Its *sense of hearing* is very acute, and the eyes, situated on both sides of the head, are very effective in spotting danger.

It is difficult for dogs to scent a hare because, except in the paws, it has few *sweat glands.*

The doe (female hare) has two or three litters within one summer. Unlike rabbits, the young hares (leverets) are born in the open and have no nests for their protection. The leverets are more developed than young rabbits. They can see, the ears stand erect, and their bodies are coated with thick grey fur.

Soon after birth, having sucked their fill of the mother's milk (which has six times the fat content of cow's milk), the leverets are placed in a "form" well hidden in the grass. There they lie quietly, protected by the colour of their fur and the almost complete absence of sweat glands. In some 3 or 4 days, when they become hungry, they leave the "form" and find their own mother, or some other doe, to suckle them. Teeth appear in about 8 or 9 days, and then the leverets are able to eat grass.

The *Grey Hare* prefers warm, open places. It is rather larger than the White Hare and is different in colour. In winter its back remains grey and only the two sides turn white. This colouring protects it only in areas without much snow.

Grey Hares can do damage by gnawing the bark of fruit-trees.

Ground Squirrels (Susliks). The Small Suslik, the Spotted Suslik (Fig. 142) and their relatives are among the most destructive of field pests.

These animals are commonly found in the steppe. In summer they often may be seen sitting upright on the sides of roads, ready to dive into their burrows at the first hint of danger.

Susliks live on seeds and the stalks of cereals. When colonies are large they considerably reduce harvests. *Small Susliks* damage pastures, consuming the most important vegetation.

In winter, when the steppes and fields are snow-covered and food has become scarce, susliks retire to their burrows block the entrances and fall into a long sleep. Hibernation is a period of almost

complete inactivity. Metabolic processes are reduced to a minimum. The heart action slows down until it appears almost to have stopped; breathing becomes almost imperceptible. The temperature drops to +4°C (and less). The susliks appear stiff and lifeless.

The young (litters of 6—8 and more) are born about 3 or 4 weeks after the animals wake up. The female makes ready a warm bed deep in a burrow. The young are blind at birth but grow fast and in about a month's time are able to fend for themselves. Then they leave their parents and dig burrows of their own.

Efforts are made to exterminate these pests by trapping them, laying poisonous baits in their burrows, etc.

Mice and Rats. Mice and Rats are found in all parts of the world. They live on scraps of human food and belong to the *mouse family of rodents* (Fig. 142).

The *Brown Rat* is bigger and heavier than the ordinary House Mouse. It has a long, scaly tail from which short hairs protrude from between the horny scales. As a rule, it hides under floors, in cellars and inside walls. Brown Rats can cut through wood with their sharp incisors, and are thus able to enter buildings. They infest the holds of ships and are carried very long distances.

Rats live entirely on vegetable and animal food products, stored by human beings, and are therefore a great nuisance in storehouses and homes.

Brown Rats reproduce extremely rapidly. A female has 4—5 litters a year, each of 6 to 8 young. It prepares a comfortable nest for its young which are born blind and hairless, but develop fast and are able to reproduce in 3 months. Rats live for 2—3 years.

The *House Mouse* is a most destructive gnawing animal, which is found in or near human dwellings and in fields. Its relatives—the long-tailed *Field Mouse*, *Wood Mouse*, and *Meadow Mouse* (Fig. 142) which has a shorter tail than the House Mouse, also cause much damage.

Susliks and other rodents are also a menace in that they carry plague by means of parasitic fleas.

Fig. 142. Rodents that are agricultural pests.
1. Spotted Suslik. *2.* Brown Rat. *3.* House Mouse. *4.* Meadow Mouse.

Control Measures. Harmful rodents are being exterminated on a large scale in the Soviet Union. They are caught in traps, killed in their burrows and holes, and given special baits (for instance, poisoned oats).

Biological control consists in encouraging their natural enemies: birds of prey, hedgehogs, polecats, etc. This method is very effective: one family of polecats may kill up to 800 susliks in a year, going into their burrows in summer and winter.

Another way of limiting the spread of gnawing animal pests is to deny them food by keeping it so they cannot get to it. Grain crops should be harvested in good time and securely stored.

Questions: 1. Why do we say that squirrels are adapted to live in trees? 2. Why is it important for the White Hare to change colour in winter? 3. How can you explain the fact that young rabbits are born bare and blind, while young hares are covered with fur and can see? 4. Why do susliks hibernate in winter but squirrels remain as active as ever? 5. What measures are taken to exterminate rodents?

Classification of Rodents. Members of this order: rabbits, squirrels, hares, ground squirrels (susliks), mice and rats have common features. They are all vegetarian. They have typical teeth: the deep-set sharp incisors, which though they wear down with use grow continually throughout the animal's life, and the broad cheek teeth used for crushing and grinding food. There are no *canine* teeth.

Rodents are comparatively small and breed remarkably fast.

Moles and hedgehogs—which are obviously related to each other—are classified as *insect-eaters* (*Order Insectivora*), and the numerous bats as hand-winged animals (*Order Chiroptera*).

Together with other orders they form the Class Mammalia, or mammals.

Animals which belong to one order need not necessarily be identical. Rabbits and hares differ from other rodents not only in outward appearance but also in that they have a pair of *small incisors* on the upper jaw, behind the big ones. The front teeth (incisors or biters) are large and prominent, and have a hard enamel surface on the front and back. (Other rodents have no enamel on the back and sides of their incisors.) These distinctive features enable us to place hares and rabbits in one *family*: *Lagomorpha.* Similarly, mice and rats belong to one family on the basis of their resemblance to each other and the ways in which they differ from hares and rabbits. They belong to the *family Myomorpha.* Squirrels and susliks belong to the *family Sciuromorpha.* In short, the Order Rodentia falls into three families: Lagomorpha, Myomorpha and Sciuromorpha.

This does not mean that members of one family have identical habits and anatomy. Young rabbits are blind and born in nests in underground burrows. Hares prefer to stay in the open; the leverets have well-developed eyes and are covered with fur. Families are therefore divided into *genera.* In the family Lagomorpha there are two distinctive genera: *genus rabbits* and *genus hares*; in the Myomorpha—*genus mice* and *genus rats*; in the Sciuromorpha—*genus squirrels* and *genus susliks.*

Classification of Order Rodentia

Class	Order	Families	Genera	Species
Mammalia	Rodentia	Lagomorpha	hares	White Hare
				Grey Hare
			rabbits	Wild Rabbit
		Sciuromorpha	squirrels	Common Squirrel
			susliks	Spotted Suslik
				Small Suslik
		Myomorpha	mice	Wood Mouse
				Field Mouse
			rats	Brown Rat
				Black Rat

Animals which belong to the same genus may also differ from each other. There are White and Grey Hares. The White Hare lives in wooded districts and has a white coat in winter. The soles of its feet are larger and more thickly furred, and well adapted for movement on soft snow. The Grey Hare has a heavier body, lives in the wooded and bare steppes, and only partially changes its colouring for winter. These hares belong to different, though related *species.*

In biological science each distinct kind of animal receives two names which together constitute the scientific name of the species: *White Hare, Grey Hare.* The name written first is the name of the genus; the second is the specific name.

A species is defined as a group of animals identical in anatomy and mode of life, which reproduce in a similar way. All animals belonging to the same species are closely related.

Questions: 1. What families and genera come within the Order Rodentia? 2. What species belong to genus mice, genus rats, and genus susliks?

§ 75. ORDER CARNIVORA (FLESH-EATING MAMMALS)

To this order belong mammals which mostly eat animal flesh. They prefer to hunt live prey. Some of these animals are very big. The most characteristic representatives are cats, wolves, dogs, foxes, bears, lions, tigers, etc.

Domestic Cat. The *Domestic Cat* originated from the *Native Wild Cat of Nubia*, whose descendants are still found in Africa. It was domesticated centuries ago, in Ancient Egypt, and is still being used by man to destroy mice and rats, thereby retaining all the features of a flesh-eating mammal preying on other creatures.

When hunting mice the Domestic Cat uses the same means as its wild ancestors. It lies in wait, crawls stealthily, and then leaps on its prey. It has a remarkably keen *sense of hearing* and *sharp eyesight*. The outer ears are flexible and catch even the faintest sounds made by a mouse. The pupils of the eyes, narrowed to a vertical slit in daylight, look enormous and round at night. Cats see well in twilight and darkness.

The *organs of perception*—long bristle-like hairs near the mouth (*whiskers*) and above the eyes (*brows*)—assist the animal greatly when hunting in the dark.

Since the toes rest on soft, leathery *cushions*, the animal is very light on foot and able to approach its prey unnoticed. Cats catch and hold their prey with very sharp curved *claws*, which are withdrawn into sheaths above the cushions when not in use or when the animal walks. In this position they are protected, do not touch ground and therefore do not become blunt.

The prey is killed by the powerful *canine teeth*, which are conical-shaped and very sharp. The body of the prey is broken up by the cutting teeth (Fig. 143). The surfaces of the cutting teeth are not flat (a characteristic feature of rodents) but extensively *serrated*. The two *front teeth, used for killing*, are especially large and act as

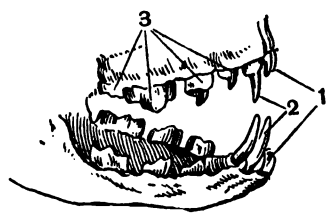


Fig. 143. The jaws of a cat.
1. Incisors. *2*. Canines. *3*. Cheek teeth.

Fig. 144. Wolves.

scissors: the sharp edge of the upper tooth glides along the outer surface of the one below. With these teeth the cat has no difficulty in tearing apart muscles and tendons. The molars are used to bite off pieces of raw flesh, the animal bending its head from side to side as it does so. The *incisors* are not big—a feature common to all beasts of prey.

The *intestines* are short (this is also common to all carnivorous animals), especially if compared with those of the rodents. Animal food is very nutritious and easily digested. The *blind gut* is not well developed.

The *brains* of all carnivorous animals are more highly organized than those of the rodents. This is due to the practice of hunting live prey. The *hemispheres of the forebrain* are covered with *convolutions*, giving increased surface area. Cats easily form *conditioned reflexes*. If, for instance, a cat is fed during dinner, it will soon come running into the kitchen at the first clatter of dishes. Cats easily remember their names. They can also be taught tricks, which they perform on request (give something they like to kittens and they will willingly jump over your outstretched arm).

Cats often suffer from ringworm, which is very infectious. Do not take cats into your hands and play with them (ringworm is often hardly discernible.)

Wolves. Wolves hunt in a different way from cats (Fig. 144). When they *hear* or *scent* their prey, they run it down in the open. Sometimes they hunt in packs. Their legs, which are longer than a cat's, are very powerful. The claws are blunt and cannot be withdrawn under sheaths.

The *teeth* are typically carnivorous: small *incisors*, huge *canines*, sharply serrated *molars*. The jaws, however, are more drawn out

than those of cats, and the number of molars greater. (That is why the muzzle is elongated.)

The she-wolf generally produces from four to nine cubs in spring, which join their parents in hunting expeditions the following autumn.

Wolves are widely distributed in forests and in the open country. They are fierce, dangerous animals, which kill a lot of domestic stock (particularly sheep). They are known to attack people.

One of the most widespread diseases among wolves is rabies. People bitten by infected wolves become ill unless they are vaccinated in time.

In the USSR a large-scale drive has been launched to exterminate wolves. They are trapped with stringed flags, and are killed from planes and helicopters. A reward of 50 roubles is paid for each scalp plus the price of the hide.

Dogs. Wolves are the ancestors of the *Domestic Dog* (Fig. 145), the first animal to have been tamed by man. Some German Sheepdogs for instance, resemble their forefathers very closely even today.

Dogs, like wolves, have powerful legs and elongated muzzles.

Man has changed the nature of dogs and evolved many different breeds to suit his own requirements. Breeds are distinguished by specific size, body shape,

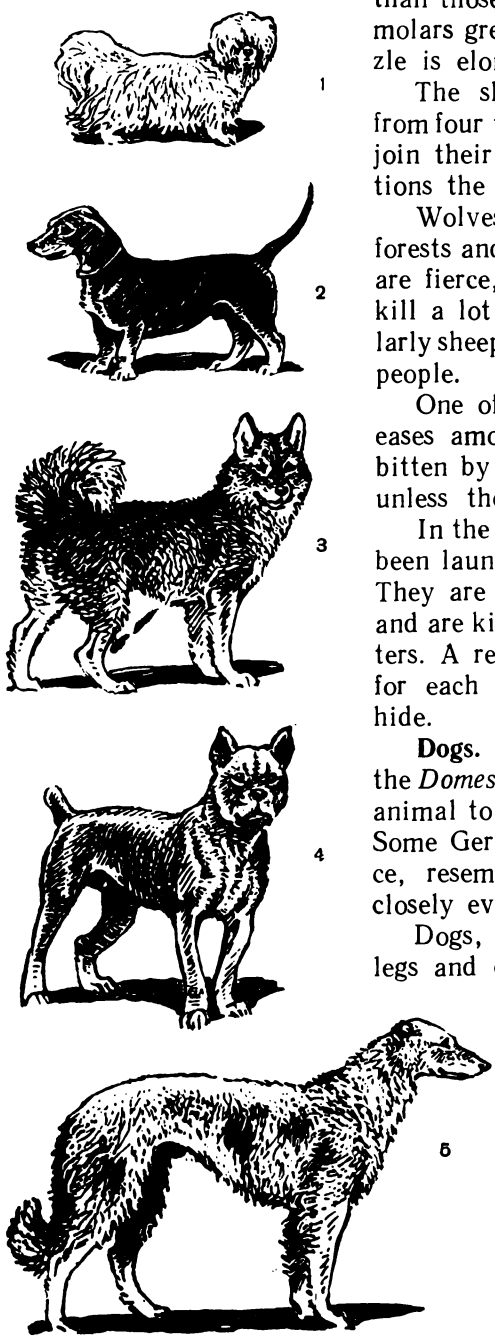


Fig. 145. Dogs of different breeds.

1. Toy Dog. *2*. German Badgerdog. *3*. Sleigh Dog. *4*. Bulldog. *5*. Greyhound.

colouring and type of fur, and also behaviour and disposition. Dogs easily develop *conditioned reflexes* and are trained for hunting, transporting cargoes, searching for criminals, etc. Laika and Strelka were sent into outer space to find out the effects it has on living beings. When handling dogs do not forget that they may infect you with echinococcus.

Brown Bears. The anatomy of the *Brown Bear's* teeth places it in the order of carnivorous animals, but in fact it eats a great variety of food—animal and vegetable. Bears have been known to attack domestic cattle. (See inside front cover.)

The bear's teeth have been adapted to a varied diet. The canines are as big and sharp as in other beasts of prey, but the molars (cutting teeth) are blunter than a cat's and the serrated surface is used for grinding vegetable food.

Huge and apparently cumbersome, the bear can run quite fast and can even climb trees. It walks on the bare soles of its feet. The bear is a *plantigrade animal*, as distinct from other flesh-eaters which tread on their toes. The bear can also walk on its hind legs using the fore legs for defence or attack.

In winter, when there is practically no food, the bear retreats to its lair under upturned roots of trees. It does not hibernate in the full sense of the word, because at the slightest disturbance it walks out. The colder months are spent without fresh supplies of food at the expense of fat accumulated in autumn.

The female generally has a litter of 2—3 small cubs in mid-winter, which grow very slowly until spring.

Classification of Flesh-eaters. Animals which belong to the Order Carnivora have a number of most distinctive features in common. They can be easily recognized by their teeth: the *incisors* are small, and the *canines* are well developed and strong; the *cheek teeth* (*cutting teeth*) are serrated.

The Order is divided into several families: 1. *cats* (domestic cats, lions, tigers); 2. *dogs* (domestic dogs, wolves, foxes); 3. *bears* (brown bears, polar bears); 4. *weasels* (marten, sable, ermine).

Questions: 1. What are the habits and structural modifications of the cat which lead us to say that it is a carnivorous animal? 2. Are the hunting habits of cats and wolves similar? 3. How is the diet of bears reflected in their teeth? 4. Why are bear cubs small and why do they grow slowly until spring? 5. Into what families is the Order Carnivora divided?

§ 76. ORDERS PINNIPEDIA AND CETACEA

Mammals that are adapted to an aquatic existence, i.e., seals and whales, belong to the *Pinniped and Cetacean Orders.*

Pinnipeds. *Seals* (Fig. 146) inhabit the seas and some of the larger lakes, where they find their favourite food—fish. They swim with ease and are expert divers. When they come out of the water (to rest or breed) they experience great difficulties. They return to the water at the slightest sign of danger.

The oblong, tapered body, which has a small head and short neck, easily cleaves waves. The limbs have been modified into *flippers* and are effectively used as fins. They have also become shorter and the toes are webbed with a skin membrane.

The fur is glossy, close and bristle-like, and does not absorb water or provide any hindrance to swimming. The animal is protected from excessive cold by a large reserve of fat under the skin which serves to retain the heat of the body. The outer ears are either poorly developed or absent. The auditory canals and nostrils close when the animal submerges.

Though they live in the water, seals are true mammals. They are warm-blooded, have lungs and a four-chambered heart. They rise to the surface to breathe every 10 minutes. The flippers contain bones similar to those of the limbs of other mammals.

During the breeding season seals come onto the land. The cubs are suckled by their mothers and have long, white, woolly coats. They cannot swim until these are shed. It is evident that at one time the ancestors of these animals lived on land, and later changed their environment.

Questions: 1. Why do we say that seals have become adapted to live in water? 2. What are the indications that their ancestors were land mammals?

Whales. Whales are still more dependent on water than seals: they spend their entire lives in it. The name is generally applied to a number of animals, of which the giant Blue Whale is the largest (Fig. 147). Blue Whales are found in all the world's oceans. A *Blue Whale* may reach a length of 33 m. Some specimens weigh over 100 tons, i.e., as much as 25 elephants or 100 oxen. The tongue of

Fig. 146. Female seal and cub on an ice-floe.

a whale may weigh up to 1.5—2 tons; the liver about 1 ton, etc. Whales are not only the largest of all animals alive today but also of all that have ever lived. They can exist only in water because there they weigh less than in the air. If occasionally a whale is stranded on a beach during a storm, it is unable to return to the sea and dies.

A whale is shaped like a fish. The body is neckless, and the huge head is directly connected to the trunk, which gradually passes into the tail.

Their anterior appendages have been modified to become *flippers* and they resemble the fins of fishes. They act as rudders. The most important organ of locomotion is the *tail*, which ends in the great leathery *tail-flukes*. The tail-flukes are placed horizontally (in this whales differ from fishes), and move up and down helping the huge animal to come to the surface and descend to great depths very fast. The posterior limbs have been lost. Only useless remnants (small pelvic bones) buried deep in the body are left. On the back of the Blue Whale there is a small fin.

Whales have lost the thick fur coats that other mammals have, except around the region of the mouth. This reduces friction when they swim.

There is practically no heat loss at all from their great bodies because just under the skin is a *thick layer of fat* (*blubber*) which acts as an insulator against cold and also diminishes their specific body weight (fat is lighter than water).

Whales feed on small crustaceans and molluscs which are consumed in enormous quantities (a whale's stomach can contain about a ton of these animals).

The Blue Whale is toothless. However, its broad mouth is equipped with numerous sieve-like *horny plates* called *whalebone*, which hang from the roof. The Blue Whale takes in a huge mouthful of water—along with the small animals that may be in it, and forces the water out through the plates, retaining the animals which it swallows.

Though whales are well adapted to their aquatic environment they nevertheless have to come to the surface every ten-fifteen minutes for a supply of fresh air. When a whale is ridding itself of the old

Fig. 147. Blue Whale.

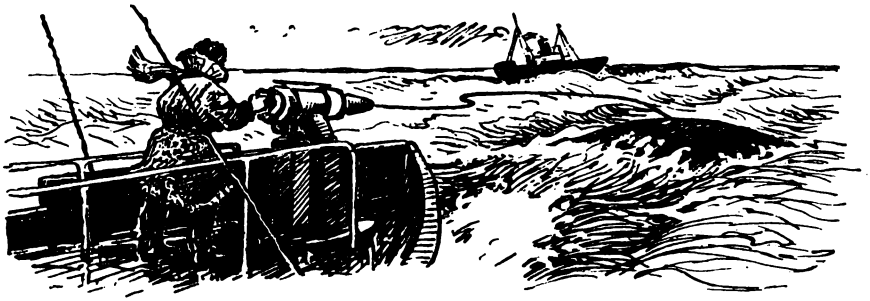


Fig. 148. Whale hunting.

used air (this is called "spouting"), its breath is puffed out through the nostrils as a warm vapour which immediately condenses in the cold air and appears as a mist. With splashes of water, this looks like a fountain and betrays the whale's presence from afar. The *lungs* are of very great size, therefore the whale can afford long intervals between two successive inhalations. The nostrils are placed on the top of the head, and are the first to appear on the surface of the water. When the animal dives they are closed by muscular contraction.

The position of the *larynx* is near the ends of the nasal passages. Passing through the nasal passages air enters the larynx, then the trachea and finally the lungs. This explains why water swallowed along with food never penetrates into the organs of respiration.

A pair of whales usually breeds every two years. When the young is being born the mother raises the tail end of her body above the water so that the young whale may gulp in some fresh air before it falls into the water. A newly-born whale is normally 7—8 m. long and weighs over 2 tons.

The young are suckled in the water and take a daily ration of 200—300 litres of extremely fat *milk* (fat content 40—50%, 10—12 times higher than in cow's milk). The "baby" grows fast. By the end of the first year it doubles in size.

Since whales give birth to and suckle their young they are mammals (despite aquatic existence). Their ancestors lived on land—which is evident from the fact that whales breathe fresh air, have remnants of hair (more prominent in the embryonic stage) and rudimentary pelvic bones. Embryos of Blue Whales have traces of teeth.

The whales are divided into two groups: *toothed* and *whalebone.*

The Blue Whale is one of the whalebone whales.

Among the toothed whales is the *Sperm Whale*, which is also very large and feeds on cephalopods (octopus, etc.), the comparatively

smaller *Dolphin* (1.5—3 m.), which eats fish (a species common in the Black Sea).

Commercial Importance. Seals and whales are animals of *commercial value.* They are hunted for their oil, skin, etc.

Seals are caught off the coasts of the northern seas and in the Caspian.

Whales, which are particularly important, are killed in great numbers (several thousands) every year in the Far Eastern seas and the Antarctic. Whaling is carried on from small boats (whalers) equipped with harpoon-guns (Fig. 148). The dead animals are delivered to floating factories, where they are cut into pieces and processed for oil, whalebone, whale meat (canned), etc. One Blue Whale produces about 20 tons of oil.

Questions: 1. Why do we say that seals are suited to live in water? 2. What is there to indicate that the seal's ancestors were land vertebrates? 3. Why do whales never swallow excessive amounts of water, along with their food? 4. Why are whales able to live in an aquatic environment?

§ 77. ORDER ARTIODACTYLA (EVEN-TOED HOOFED MAMMALS)

Bulls and Cows. *Bulls* and *cows* are domestic cattle. They are big, heavily-built animals. Their legs, which are long and massive, end in two *hoofed toes.* Above these, on either side, are the remnants of two smaller ones. The hoofs spread out sideways when the animal walks on damp soil, helping to prevent it from sinking. Mammals that have such hoofs are called *artiodactyls.*

Cattle have big, horned heads and bulky necks. The *horns* are hollow and rest on bony extensions from the skull. In pre-historic times the ancestors of present-day cattle used them to protect themselves from beasts of prey, for instance, wolves.

The long tail, tufted at the end, is used to brush away insects.

Food is strictly vegetarian. Since it has poorer nutritive qualities than animal matter, the organs of digestion have been modified to deal with much greater amounts.

The cud is chewed with big *cheek teeth* which lie far back in the mouth—6 on each side of the jaws (Fig. 149). These teeth are flat with slight ridges of enamel on the upper surface. The front teeth—*incisors* and *canines*, which closely resemble them—grow only on the lower jaw and are separated from the back teeth (molars) by a toothless gap. There are no front teeth (incisors or canines) on the upper jaw. Instead, it has a membranous pad. When grazing, the animal tears off grass by taking it between the lower front teeth and the membranous pad.

The cropped food is swallowed unchewed. Well mixed with saliva, it goes down into the *stomach* which has a somewhat complex anatomy (Fig. 150).

The stomach is divided into four parts: the paunch (or rumen), the honeycomb bag, the manyplies, and the belly (or reed). True digestion takes place only in the belly whose walls contain glands which secrete digestive juices. The first three parts are actually an enlarged gullet and are known as *forestomach*. They are not present in young calves.

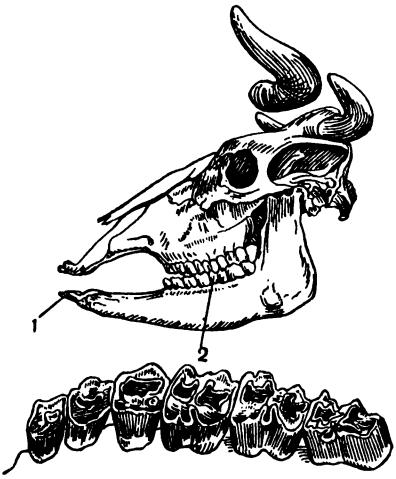


Fig. 149. Skull of a cow.
1. Incisors and canines on the lower jaw.
2. Cheek teeth.

The food first enters the *paunch*, which can hold between 150 and 200 litres. This makes it possible for the animal to take in large amounts of grass in a very short time. Then the food passes to the *honeycomb bag*. In both the paunch and the honeycomb bag, it is reduced to a soft pulp, while the wall tissues of the plant cells undergo certain changes under the influence of bacteria and certain simple animals.

After some time the food, which by then has been squeezed into balls (or the cud), is regurgitated into the mouth where it is chewed. When chewing, the lower jaw of the cow is moved from side to side (but not up and down).

The food, rechewed and thoroughly mixed with saliva, becomes semi-liquid, and when swallowed, goes direct into the *manyplies*, from which it slips into the last compartment, the *belly*, whose walls secrete gastric juice.

After the stomach comes the *intestine*, which is 20 times as long as the animal's body. Ducts of well-developed *intestinal glands* empty into the walls of the intestine. Here, under the influence of their juices, as well as liver bile and pancreatic juice, the process of digestion is completed and *absorption* by the blood of the end products of digestion occurs.

Even-toed hoofed animals having such a complex stomach are called *ruminants*. Ruminants include *cows*, *deer*, *sheep*, and *goats*.

Another characteristic of the cow is the presence of efficient milk-secreting (mammary) glands. Two pairs of these glands form the udder which has four teats. Milk is formed by the mammary glands

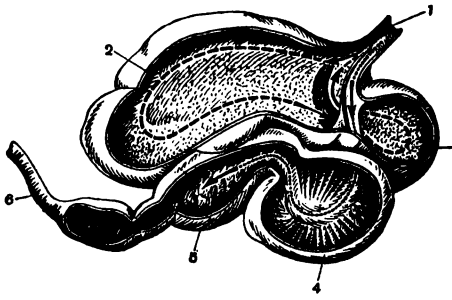


Fig. 150. Stomach of a cow.
1. Gullet. *2*. Paunch (rumen). *3*. Honeycomb bag. *4*. Manyplies. *5*. Belly (reed). (The passage of food is shown by the dotted line and the arrows.)

and secreted through the openings at the ends of the teats. High-yielding cows usually have well-developed udders into which large blood vessels carrying blood rich in nutritive substances open. The substances are used in producing milk.

In the remote past cow's milk was used only to suckle calves. Domestic cows do this for a short period only after calving. Usually when a cow calves she gives birth to one calf which is soon strong enough to follow its mother. This ability was most important for the wild ancestors of the present-day cow, when young calves had to be as fleet of foot as their parents to escape enemy pursuit.

Questions: 1. To what order do cows belong? Why? 2. How many parts are there in a cow's stomach? 3. Why is the structure of the cow's stomach so complex? 4. How long is the cow's intestine?

Reindeer. These animals (Fig. 151) are found wild and have also been domesticated. They are especially adapted for living in the tundra, with its swamps, scanty vegetation and long, rigorous winter.

A reindeer is a big animal with long legs. It is capable of travelling at great speed.

The toes are capped with h ard, horny *hoofs*. Of the four toes, the inner two are more powerful than the others. All are hoofed. The hoofs can spread out sideways, thereby forming, together with the smaller remnants, a broad support. The reindeer can run with ease over the snow in winter and the marshes in summer.

The head is crowned with large bony *antlers*, branching and solid, which are shed every year and grow afresh in a few months. All deer have antlers. At first they have a "velvet" covering of skin which later shrivels and peels off. With the exception of the reindeer, females do not have antlers.

The body (including the point of the muzzle, generally bare in other deer) is covered with thick fur. The new fur which grows after shedding the old coat in autumn proves an excellent protection against the severe northern cold because it retains much air.

In the tundra vegetation is not abundant, but the reindeer "do not complain". In summer they eat the leaves of low-growing bushes and

grass, and in winter their diet is limited to reindeer lichen. They find lichen when they clear away the snow with their strong hoofs.

The reindeer is a *ruminant*. Its digestive organs are similar to those of a cow.

One (rarely two) fawn is born every year, and is developed enough to be able to run after its mother a few hours after birth.

Domesticated reindeer are invaluable in the tundra. People rely on them for food (milk and meat), clothing, footwear, and transport. Reindeer breeding is an important branch of Soviet economy in northern regions.

The domesticated breeds differ little from their wild relatives, but they have thicker and longer fur and weaker antlers. The similarity can be explained by the fact that their living conditions are almost identical. Both breeds live in the open and have to forage for food throughout the four seasons of the year. However, herds of domestic reindeer are protected from enemies and driven to better pastures. Of course, they are also kept under veterinary observation.

Questions: 1. Why can a reindeer live in the tundra? 2. Why is a coat made of reindeer fur so warm? 3. Why is there little difference between a wild reindeer and a domestic one?

Wild Boar. The *Wild Boar*, which is actually a *wild pig*, is still found in thick forests and reedy places (Fig. 152).

Its body, which is rather long, rests on short legs. The head is pointed towards the snout. These features help the animal to run with ease through the densest thickets.

The feet have 4 toes armed with horny hoofs (a feature common to all even-toed hoofed mammals). The two inner toes are better developed than the outer ones, which are smaller and placed a little

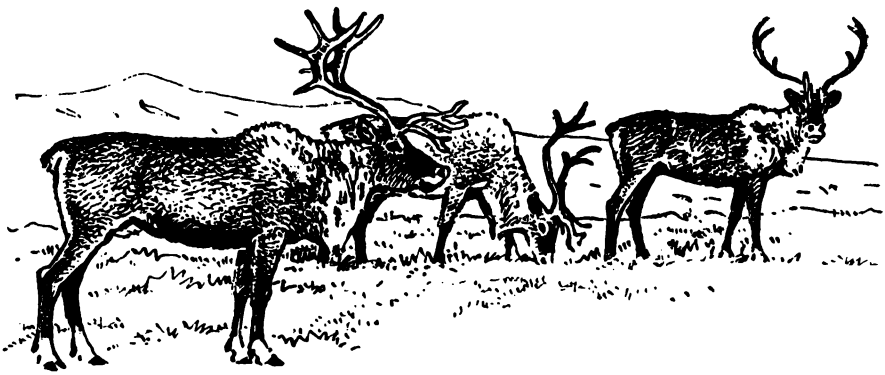


Fig. 151. Reindeer.

Fig. 152. Wild Boar.

higher. When travelling over marshland, the animal spreads out the inner toes (as does the reindeer) and, using the lateral ones as well, does not sink into the ground.

The skin is thick and covered with *bristle-like hair*, which never gets entangled in branches, and never gets wet. However, such a "coat" is a poor protection against cold. The temperature of the body is kept even by a thick layer of *fat right beneath the skin.*

There is plenty of food for Wild Boars in the forest. Unlike other hoofed mammals, they eat everything: grass, acorns, roots, insects and insect grubs, and mice. They find part of their food on the surface, but also root up the ground with their long *snouts* which have a small round, cartilaginous coin-shaped tip. The head is heavy and supported by powerful neck muscles.

The teeth are adapted for dealing with all kinds of food. They use their big *tusks* to get out roots of plants found in the earth. In the males these are long, formidable, curved, project beyond the mouth, and are used for defence and attack. The *incisors* are rather large and bent forward, and serve to bite off food or pick it up from the ground. The *cheek teeth* are serrated and can grind vegetable and animal matter.

The stomach is simple. Food is not regurgitated back into the mouth. The Wild Boar belongs to even-toed hoofed, non-ruminants.

The sow gives birth to a litter of 4—6 young a year.

The domestic pigs of today have descended from Wild Boars.

Questions: 1. What modifications in the Wild Boar's anatomy reflect its environment—jungle and swamps? 2. What is there in common between the Wild Boar and other even-toed hoofed mammals? How is it different from ruminants?

§ 78. ORDER PERISSODACTYLA (ODD-TOED MAMMALS)

Horses are one-toed—each leg has only one functional toe capped with a horny hoof. This is why these animals belong to the *odd-toed mammals.*

The only wild horse in the world today is the *Przhevalsky Horse* (Fig. 153), which lives in the steppes of Central Asia and has been so named in honour of the famous Russian traveller N. M. Przhevalsky by whom it was discovered.

With the exception of certain parts, the beautiful, graceful body of the domestic horse is covered with rather short hair. It has longer hair on the head (forelock) and along the neck (mane). It has a long tail, which is most effective for brushing away flies and gadflies. The tail is also of hair. The Przhevalsky Horse has a shorter mane and no forelock.

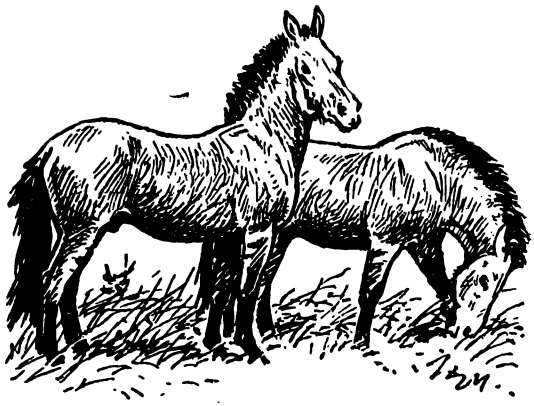


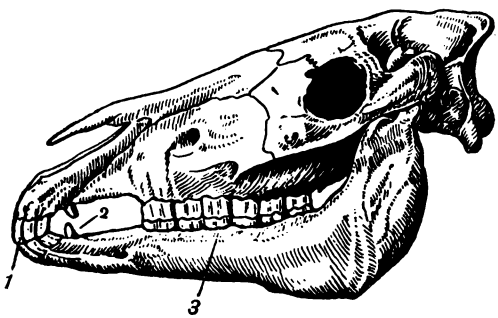
Fig. 153. Przhevalsky Horses.

In pre-historic times wild horses lived in the open country. Since there was nowhere to take shelter from their enemies, they had to rely for survival on their swiftness and endurance. They travelled long distances in search of food and water. This mode of life had its effect on the anatomy of their limbs. After a series of gradual transformations *one toe* (and its "nail") *in the middle of each limb* became much larger than the others. This gave the legs firmer support, making it possible for the body to move forward more easily. The horse became a fast runner. Paired remnants of toes are still present, however, in the skeleton of the legs indicating the modification.

The early ancestors of the horse had three toes, and the earliest ones even five. This has been established by examining unearthed fossils.

Gradually there has been a reduction in the size of all but the central toe. Now nothing remains save paired bones hidden under the skin.

Due to its well-developed sense of hearing and eyesight, the horse becomes aware of the presence of enemies in the steppe from afar.



The horse eats vegetable food, and its teeth and intestine have been adapted accordingly. Big jaws, which give the head an elongated shape, bear 12 *incisors* in their front parts: there

Fig. 154. The skull of a horse. *1.* Incisors. *2.* Canines. *3.* Cheek teeth.

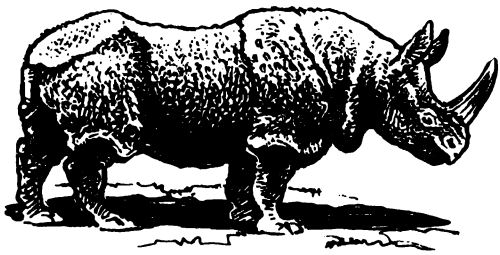


Fig. 155. Rhinoceros.

are six in both the upper and lower jaws. They are set close together and are directed forwards (Fig. 154). While grazing, the animal takes the grass between its soft lips, bites it off with the incisors, at the same time making a sharp movement sideways with its head. Small *canines* are present only in stallions and are separated from the cheek teeth (molars) by toothless gaps. The *molars* (six on each side, in the upper and lower jaws) lie deep in the mouth. These back teeth are broad, quadrangular and flat, the upper surfaces being covered with ridges of hard enamel. They act as millstones, grinding food well mixed with saliva.

The *stomach* of the horse is large but is not divided into separate parts, like the stomach of a ruminant. Food is stored in the long *blind gut* to be fermented. (What other animal has a well-developed blind gut?)

The mare gives birth to one foal at a time. It is soon strong enough to follow its mother. In ancient times this was essential in the open plains where the young could find no shelter from enemies.

Other odd-toed animals are *the donkeys*, *the zebras*, and *the rhinoceros* (which has three toes, Fig. 155).

Questions: 1. What evidence is there to indicate that the early ancestors of our domestic horses lived in open country? 2. Why can we say that horses are adapted to living on vegetable food?

§ 79. ORDER PROBOSCIDEA

There are only two members of this order: the *Indian Elephant* and the *African Elephant*. They are the largest of the world's land animals.

The Indian Elephant (Fig. 156) is on the average 3 m. high and weighs over 4 tons.

Indian Elephants prefer to live in shady glades in tropical forests, where they roam with great agility.

The huge (but comparatively short) body of the Indian Elephant is supported on bulky, column-like legs terminating in small hoofed toes. The skin, which is very thick and almost hairless, is so strong

that it is never scratched by the sharp edges of broken branches. Hair grows only on the tip of the tail and in a few places on the back.

The order owes its name to the unique characteristic of the elephant—its *proboscis*, called *trunk*, which is actually a greatly elongated nose, merged with the upper lip. This organ has become extremely flexible (muscles are interlaced) and can be turned in every direction. It is used to break off branches and convey them to the mouth; to draw up water to drink or give itself a showerbath in hot weather. The trunk is powerful enough to uproot a tall tree; the *finger* at its tip is so delicate as to be able to pick up the smallest objects. The trunk also serves as a very efficient weapon against possible enemy attack. Breathing is effected through the *nostrils*, which are located at the tip of the trunk.

Elephants exist on vegetable matter: on leaves, grass, and the twigs and bark of trees, etc. Food is consumed in enormous quantities. In the Moscow Zoo, for example, each member of the elephants' colony is daily provided with about 65 kg. of hay, vegetables, bread, sugar and salt, and heaps of twigs. Tame elephants in India, which carry heavy loads, require even more.

The two *tusks*, which protrude from the mouth, correspond to over-developed *incisor* teeth. Among the Indian Elephants only the males have tusks, but among their African relatives the females grow them as well. The tusks are of ivory. This is a solid substance used for making billiard balls, statuettes, brooches, etc. The food is ground by four *cheek teeth*, which are very large (26 cm. long and 8 cm. broad) and lie deep inside the mouth: one on each side of the upper and lower jaws. The cheek teeth are coated with enamel which is formed into many ridges. These are capable of grinding tree branches as thick as a human arm. As they wear away new ones grow behind them.

Elephants do not reproduce rapidly. One female elephant at the Moscow Zoo had a calf in 1948 and another four years later. In captivity they generally live up to 60—80 years.

In India, elephants are used for a great variety of tasks. One of these is carrying logs. Elephants easily learn to perform tricks.

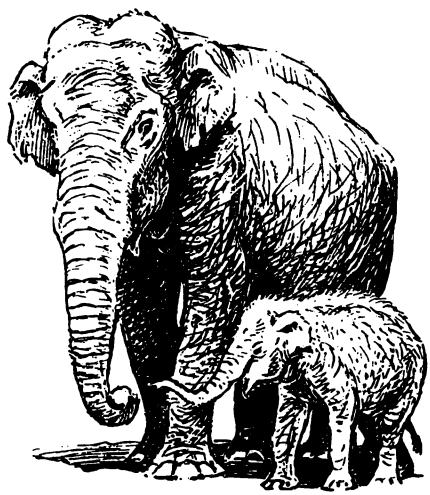


Fig. 156. Indian Elephant and calf.

The numbers of wild elephants have been greatly reduced and the animals are protected.

In the Soviet Union teeth and bones of the elephants' extinct relatives *mammoths* have been found on several occasions.

Mammoths (Fig. 1) are now extinct. In Siberia the body of a mammoth—completely preserved—was recently taken from the zone of perpetual frost. It was covered with thick red hair. The skin was stuffed and is now on view at the Zoological Museum of the USSR Academy of Sciences, in Leningrad.

Questions: 1. What part does the trunk play in an elephant's life? 2. Why is the short neck no handicap even though the legs are long? 3. What changes have the elephant's teeth undergone?

§ 80. ORDER PRIMATES

The *Order Primates*, the highest order in the animal kingdom, includes the *monkeys*. Most monkeys live in the tropical jungles of Africa, Asia and America. They include many species, but we shall study only two families—*Long-tailed African Monkeys* and *Apes*.

Long-tailed African Monkeys. The particular characteristics of monkeys are clearly shown in the Long-tailed African Monkeys.

They live in tropical forests, close to rivers and lakes. They spend most of their lives in the trees moving with great agility on all four limbs from one branch to another. The "thumbs" are opposed to the "fingers" (as in a man's hand).

It is not without reason that monkeys are sometimes said to have four arms. Their agility is exciting to observe. On the ground they walk on all fours, on the soles of their feet and the palms of their hands. The fingers and toes have nails, like a man's.

Noteworthy too is the position of the eyes which have moved to the front, making a monkey's face look very human.

The body is covered with fur, except for *patches of hard, bare skin on the buttocks* (*ischial callosities*). The tail is long.

Food consists of fruit, young sprouts, birds' eggs, and insects. They use their hands to place it in their mouths, and store some of the food they find in their *cheek pouches*, to eat at their leisure. Long-tailed African Monkeys have the same kind and number of *teeth* as man, except for the *canines* which are a little bigger.

They live in troops, each with its own leader. They are very destructive to maize and plantation crops, invading them in great parties and spoiling more than they can eat.

Living in troops offers advantages in providing food and repulsing enemy attacks.

They can easily be taught many amusing tricks. They readily develop conditioned reflexes. These capabilities are connected with highly-developed *cortex of the frontal hemispheres of the brain* where numerous convolutions can be observed.

They usually give birth to a single baby. "Twins" are rare.

Questions: 1. What is the structure of a monkey's limbs? 2. Describe the appearance of the Long-tailed African Monkey. 3. What can you say about its mode of life?

Apes. The term "ape" includes the Chimpanzee and Gorilla, which live in Africa, and the Orangutan, which is a native of Borneo and Sumatra.

The *Chimpanzee* is equally at home in trees and on the ground. During the day it is mostly on the ground, climbing into the trees at night to sleep.

It is rather tall (a little under 150 cm.) and tail-less. Most of the body is covered with black hair, only the face, ears, palms and soles are bare. The fur on the back is thicker than on the chest and belly.

The head is round and carries large ears shaped like man's. The bare face with the forward-placed eyes is also quite human in appearance, but the jaws are more protruded, the nose is flatter and the nostrils broader.

On the fingers and toes there are *nails* as in humans. The four "thumbs" are opposed to the fingers and toes. On the hands, however, the thumbs are considerably less prominent than in man. The arms are longer than the legs, which can be explained by tree-dwelling habits. Chimpanzees walk slightly bent, the body weight being carried on the soles of the feet and on the back of the second joints of the fingers. The front limbs are used when handling food, like hands.

Food consists of juicy fruit, nuts, young plants, birds' eggs, and insects. The *teeth* resemble those of man, but the *canines*, which are used for defence, are larger. The blind gut has a *worm-like appendix*, like that in humans.

The *brain* is more highly developed than in other mammals and is 19 times heavier than the spinal cord (in a dog it is five times heavier). However, it is considerably smaller than the human brain, weighing between 400 and 600 grammes, as against 1,200—2,000 in man (1,200 gr. is the minimum).

In general, Chimpanzees easily acquire *conditioned reflexes.* They can be taught to sit

Fig. 157. Chimpanzee.

at a table and use a napkin and a spoon, etc. (Fig. 157). They learn to use a stick to bring down bananas hanging from a ceiling. They assume postures and facial expressions which look quite human.

Chimpanzees keep together in family parties, constructing new nests out of twigs every evening.

The females give birth to one young at a time, and are very affectionate mothers. The life-span is estimated to be several score years.

The *Gorilla* is the largest of the man-like Apes, sometimes standing 180 cm. high. It spends most of its life on the ground.

The *Orangutan*, on the contrary, is far better adapted to living in trees. The name is a Malayan word and means "man of the forest".

Questions: 1. How do Chimpanzees move in trees and on the ground? 2. Why do we say that apes resemble man?

§ 81. HUNTING AND FUR FARMING

Hunting. Many wild animals are hunted for their pelts. In fur production the Soviet Union has no equal in the world (Fig. 158). Some types of animals—*squirrels*, *foxes*, *Arctic foxes* and *muskrat*—are the world's most prolific fur producers. The pelts of *ermine*, *sable*, *marten*, *otter* and *beaver* are warm and beautiful. The skins of *moles* and *susliks* wear out fast and are less valuable.

In Russia hunting has been practised since primitive times. Today too it is the chief occupation of some of the nationalities living in the North.

Fur-bearing animals are normally hunted in winter when after moulting they develop rich *underfur*. Hunting methods include trapping, tracking with hounds, and shooting. The mode of life and behaviour of the animal decides which method is best.

In pre-revolutionary Russia hunting was practically uncontrolled and indiscriminate, with the result that the most valuable animals—sables and beavers—were almost exterminated. In Soviet times a nature protection law was passed limiting hunting to certain periods, and the use of poisonous baits and maiming traps was forbidden. Special permits have to be obtained before hunting sable, marten and otter. It is forbidden to hunt beavers.

These measures have saved many animals from extinction and their numbers are constantly increasing. As a result, it has now become possible to hunt as many sables as a hundred years ago.

Protection and Re-settlement. To encourage rare animals to breed and reproduce special *reservations* have been established: for beavers

near Voronezh, for sables in Siberia (Barguzinsky), etc. There extensive research is carried on to learn more about the habits of the animals. In these favourable conditions for life and breeding a number of valuable animals (for example, beavers) reproduce extensively instead of becoming altogether scarce.

Food is provided when it becomes scarce: fish for Arctic foxes; aspen and hay for hares, etc.

In the Soviet Union efforts are also made to stock suitable regions with valuable fur-bearing animals. Some of the beavers are being moved from the Voronezh Reservation to other parts; while hares have been taken to Western Siberia, where they had never been before. The "re-settlement" drive has involved even sables.

A number of valuable animals have been brought in from other countries, for instance, muskrat (a rodent native to America, which has fine fur).

The muskrat leads a semi-aquatic existence. It favours sluggish rivers, lakes, and marshes, where food (roots and stalks of reed mace, water-lilies, and reeds) is plentiful. Its diet also includes molluscs and insects. Like all other rodents, the muskrat has great powers of reproduction, breeding 2 or 3 litters of 4—10 young every year.

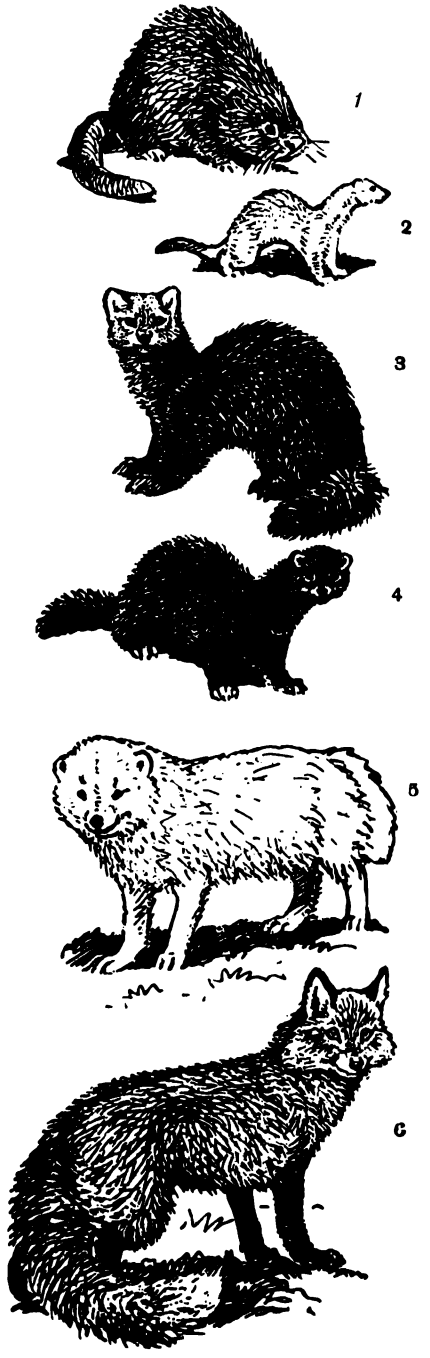


Fig. 158. Fur-bearing animals.
1. Muskrat. *2*. Ermine. *3*. Sable. *4*. Mink. *5*. Arctic Fox. *6*. Silver Fox.

Imported into the Soviet Union in 1928, this animal is found in many regions and today is yielding over 5 million valuable pelts annually.

The "re-settlement" and acclimatization drive is greatly facilitated by a scientific approach.

Fur Farming. The most valuable fur animals are raised in captivity for their pelts. Soviet collective and state fur farms breed *silver foxes*, *Arctic foxes*, *sable*, and *mink*. This new branch of economy has made rapid development, and the number of farmed animals is continually increasing.

Scientific research has made the raising of fur animals in captivity successful. Sables, for instance, began to reproduce at special farms only after their diet and behaviour had been thoroughly studied by research associates working at the Moscow Zoo. Experiments in breeding beavers in cages were for the first time successful at the Voronezh Reservation.

Zoologists are still studying the diet to be given to different animals and what measures to take to control parasitic worms (infestation often takes place). It has been found, for instance, that fur-bearing animals should not eat too much bone matter because this makes their fur too crisp and reduces its value.

Fur farming is a good illustration of the importance of a scientific approach.

Questions: 1. What fur-bearing animals are hunted in the USSR? 2. What measures do Soviet authorities take for their protection? 3. Why are reservations established? 4. Give a few examples of the re-settlement of fur-bearing animals. 5. How does science assist fur farming?

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